THE UNIVERSITY OF ALBERTA

SOME EXPERIMENTS ON KINESTHETIC BACKWARD MASKING

by

Ⓒ JOSEPH CHARLES RABEL

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF PHYSICAL EDUCATION

EDMONTON, ALBERTA

FALL, 1972

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Some Experiments on Kinesthetic Backward Masking" submitted by Joseph C. Rabel in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

The purpose of this series of studies was to determine if kinesthetic-location information is codable. There were three factors of experimental interest: masking, duration, and complexity. The experimental task required subjects to immediately reproduce kinesthetic patterns which were briefly presented. There were eight dependent variables: two simple discrimination errors, two invention errors, two ommission errors, and two gross performance scores.

The experimental design was a treatment by subjects, factorial design with two replications. The basic statistical method used to analyze the data was analysis of variance.

It was concluded that kinesthetic-location information, in STSS (Short term sensory storage), is uncodable.

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to Dr. R. B. Wilberg for the privilege of being one of his students. The writer would also like to thank Miss S. Neill and Dr. C. Bourassa for consenting to be on his examining committee.

Appreciation is also expressed to Dr. Eric Buckolz for his technical assistance, and to Miss Leslie Dunning for her faith.

A warm thankyou is extended to the other unmentioneds of the Wilberg '72, Human Performance Group.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

Human performance theory is a philosophical approach to the study of human behaviour. Based upon the premise of man as a limited processor of information, this theory attempts to analyse the processes involved in skilled performance, to identify the limiting aspects of those processes, and to establish quantitative estimates of man's abilities in each of these basic functions.

Information thoery offers a method of measurement compatible with human performance theory. Information measures describe the statistical structure of stimulus and response associations. The unit of measurement is the non-metric 'bit': the amount of uncertainty reduced. This advantage allows both an explicit relationship between the experimental question and the task components, and, generality among various experimental situations.

Recent publications concerning memory for motor tasks have been almost exclusively limited to the short-term memory (STM) interpolated task (IT) paradigm, borrowed from the verbal area. A stimulus is presented, and the delay or the IT is varied for length and complexity, respectively, before recall. Based upon this experimental approach,

several studies have been undertaken using the input modalities of vision, audition, and kinesthesis (K). The IT design has allowed the comparison of information processing capacities between modalities, and as such, has revealed the lack of understanding of K.

Kinesthesis in STM

Contrasting the retention of motor tasks with information processed through other sensory modalities, Broadbent (1957) concluded that motor responses required less central processing capacity, since they gave rise to fewer reports of conscious rehearsal.

Since Broadbent's (1957) work, research on the memory aspect of human performance has been centred upon three hypotheses concerning the etiology of the motor trace. Decay exponents claim that the trace decays with time (Adams and Dijkstra, 1966). Interference exponents claim that proactive and retroactive responses interfere with the criterion task and degrade it. Patrick (1971) concluded that the factors affecting response bias were: (i) the sign of the IT amplitude relative to the criterion length, (ii) the type of IT, and (iii) the temporal position of the IT. Finally, Posner (1967a), Posner and Konick (1966), and Pepper and Herman (1970) have proposed the "Acid-Bath" hypothesis which incorporates both of these previous views. This hypothesis predicts the loss of information over time, and that the amount of interference governs the rate of

this loss. That is, the rate of information loss is a function of both, the amount of acid (number of stored items) and its concentration (similarity). Further, this notion implies an associative STM: information is sorted and coded into dimensions of similarity and that the similar items are related in storage, so that they interact more strongly. This hypothesis of information loss processes is congruent with filtering principles (Broadbent, 1958) and with Conrad's (1964) evidence of acoustic encoding.

Implications for K in STM

Pepper and Herman (1970) attempt to explain the etiology of the motor trace. In their review of motor STM, they imposed the interpretation of a dual process of decay and interference upon the fate of the motor trace. They assumed that (i) a memory trace decays over time, (ii) the decay occurs on the dimensions of intensity or extent of response, (iii) traces interact, and (iv) S responds according to this 'assimilated' trace. The possible flaw of their logic lies in the assumption that an original trace actually exists at a conscious, retrievable level and survives until STM (20 seconds). Perhaps there is no motor STM, but rather, that movement is controlled by preprogrammed routines and reflexive control mechanisms (Konorski, 1967). Konorski's model of the voluntary control of movement is discussed in Chapter II.

If K information is undecodable (Wilberg, 1969), then it is not functional in an abstractive STM (Norman, 1970). If

so, the Pepper and Herman (1970) interpretation is surpassed by Eriksen and Hake's (1955) consideration of the nature of absolute judgements. The implication of Konorski's model and the work of Eriksen and Hake would be that a K trace does not endure consciously until STM, and consequently that the recall task is a 'continuous' absolute, and not a comparative judgement. The contention of Eriksen and Hake is that the method of absolute judgement has the inherent artifact of an anchor effect at the two ends of its continuum. Response errors to the end stimuli can only be made in one direction, and consequently, the 'range effect' results. Therefore Pepper and Herman's "Acid-Bath" interpretation may be superfluous to the constraints of the human operator.

Hinrichs (1968) used a pre- and post-cuing technique for the recall (20 seconds) of digits, and found that retention error was more influenced by the order in which the items were recalled than by knowledge of the required recall order. Crafts and Hinrichs (1971) extended this design to motor memory, and found that advance knowledge (pre-cuing), as to which movement was to be repeated, offered little benefit to recall accuracy. They concluded that trace intensity interaction takes place at a peripheral, rather than a central level, and is not under the direct control of S.

Posner (1963) suggested that studies using sequential presentation of stimuli confound the interpolated material, and the time in store. Schmidt and Ascoli (1970) concluded that although central processing capacity is not required to

hold traces in motor STM (perhaps because they do not exist there), this capacity is required to store the motor trace. The implication, is that the STM interpolated task paradigm has yielded short 'mileage' for understanding K (Schmidt and Ascoli, 1970; Wilberg, personal communication).

Further, past research on K has not delimited it as a mutually exclusive variable; when S performs a movement, several sensory modalities interact giving him a multi-modal percept. Wilberg (1969) commented,

> The assumption often implied in a formal definition or construct is that the performer actually attended to the available input information. Unfortunately for the coach or instructor, the kinds of information the student attended to are not always obvious.

Accuracy of recall of a movement for visual input only, has been found not significantly different from visual plus K information, that is, V = V+K (Posner and Konick, 1966). The unsolved problem is how much of this effect is due to the S's habitual style of handling information of different kinds, and how much may relate to differences in the physiology of the peripheral visual and K analysers. Why does V = V+K? Is it due to differential temporal levels of codability? Why does pre- and post-cuing of the criterion movement show no difference on recall (Hinrich, 1968), when visual paradigms do? Is STM the 'present state of the performer' for visual information, while STSS is for K information? Or is K a non-learning sensory system? If so, perhaps man is deterministically 'wired-in' (Rose and Mountcastle, 1959), and thus K can assume significance only

as a form of redundant information until S learns through extroceptive stimuli, at which time K aids in perfecting and automating habits (Honzik, 1936; Fitts, 1951; Fleishman and Rich, 1963; Konorski, 1967).

Basic to all of these preceding questions is the problem of the nature of K. How is it that a man can make active K adjustments without conscious awareness? That is, what is the K code?

The Problem

In order to elucidate the nature of K, the present research was an attempt to sample the fidelity of K information at the level of processing termed "sensory information store" (SIS), (Sperling, 1963) or "short-term sensory storage" (STSS) (Fitts and Posner, 1968). Four different sources of evidence are cited by Posner (1963) for the existence of a representational storage (STSS) for all modalities: (i) tachistoscopic presentation (Averbach and Coriell, 1961; Sperling, 1960), (ii) dual-channel monitoring (Broadbent, 1958; Broadbent and Gregory, 1961; Norman, 1969a), (iii) stimuli that are difficult to code in verbal form (Harris, 1952), and (iv) delay of information about the relevant response categories (Pollack, 1959).

Several studies have suggested that a discrete motor trace exists for 15-20 seconds without any degradation. If a trace exists at this stage of processing, it may be studied by Sperling's whole report technique, while trace disruption might be facilitated by the backward masking paradigm

(Sperling, 1963). Both of these designs come from visual research, where they have been extremely beneficial in the study of the temporal aspects of perception.

In summary, the purpose of this study was to investigate the information processing parameters of a K registry system (STSS).

CHAPTER II

REVIEW OF LITERATURE

A Model of Perception

Broadbent's (1958) model of man as an information processor dissects the organism into a P (perceptual) and an S (storage) system. Included in perception are those processes involved in the initial transduction of the physical signal into a sensory image, the extraction of relevant features from the sensory image, and the identification of that list of features with a neuronal model. For a brief stimulus exposure, extraction rate is determined by the clarity and the amount of 'registered' information. Hence, as the image decays, the rate of information extraction decreases. The S (or memory) system consists of those processes that transfer, store, and retrieve the material sent to it from the P system (Norman and Rumelhart, 1970; Bower, 1967; Atkinson and Shiffrin, 1968; Rumelhart, 1970).

Figure 1 illustrates a framework for the flow of information within the organism (Reitman, 1970). Fitts and Posner (1968) and Waugh and Norman (1965) divide the P system into a STSS (short-term sensory store) and a STM (short term memory). Eliot (1971) states that most information theorists regard perception as an active process with the degree to which the observer does something to the stimulus varying with both the number of stimulus dimensions

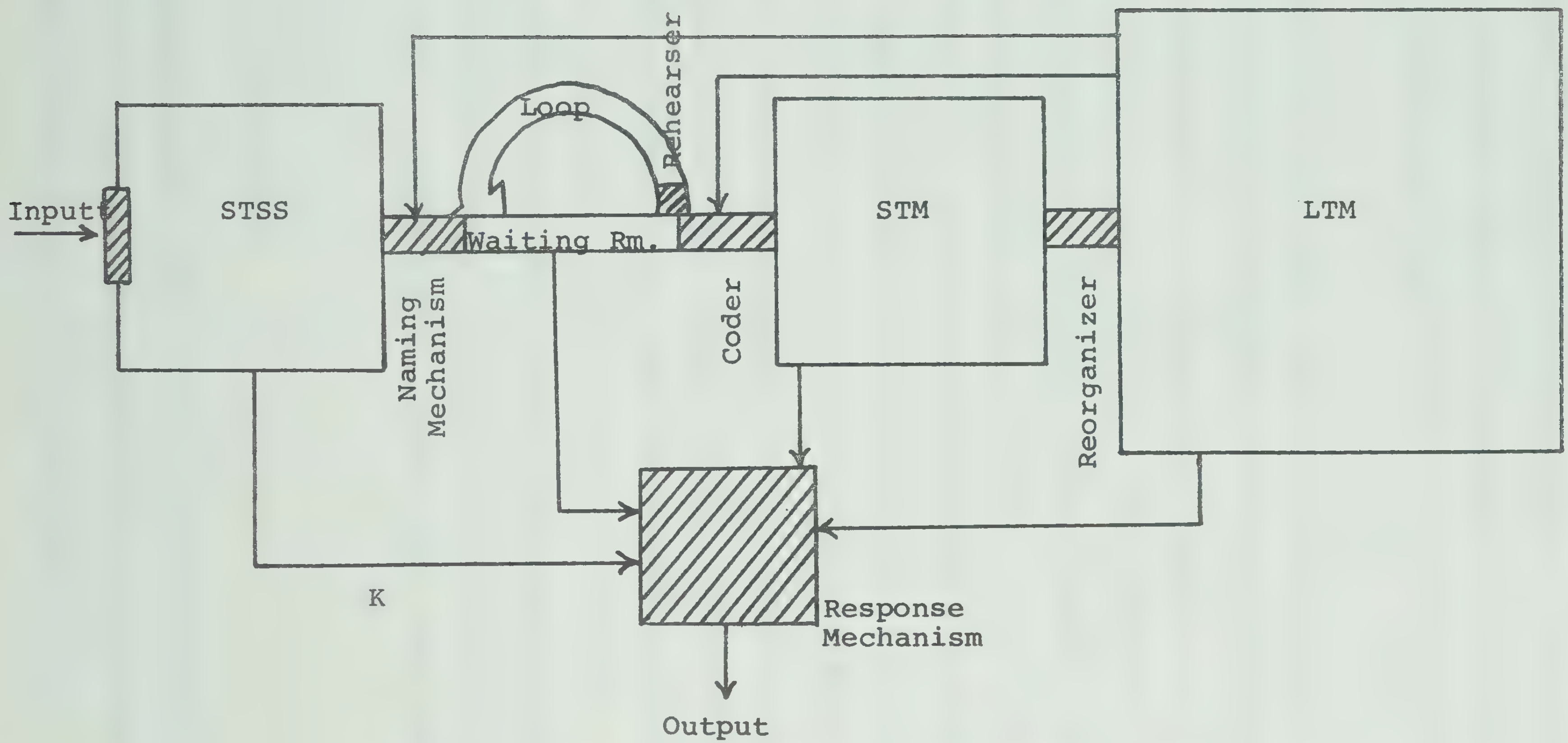


FIGURE 1 A MODEL OF MEMORY AS ADAPTED FROM REITMAN (1970)

and the task demands (including instructions). Thus, depending upon the complexity of the stimulus and the S's experience, either may dominate a particular situation. Consequently, perception consists of both active and passive processes.

Atkinson and Shiffrin (1968) and Norman (1970b) extend the idea of a combined active-passive perceptual analysis. If STSS is considered to be structurally limited as a passive set of registers serving as a rough guide to the interpretive (inferential) process, then an active STM system could resolve those conflicts left by the first system, by recourse to expectations compliant with rule and probability constraints implicit to the neuronal model: Broadbent's S system. This accounts for the veridical nature of perception. The passive system, STSS, is essential in order to analyze unexpected signals (Miller, 1968), while the active system is necessary in order to fill in gaps and distortions in the actual signal (Bruner, 1957).

Therefore, the former system would essentially be a descriptive (gating), while the later, an abstractive mode of analysis (Posner and Mitchell, 1967; Dick, 1969, 1970, 1971).

Properties of Visual STSS

Temporal Limits. The sensory register system (STSS) has been largely defined through the use of very brief tachistoscopic exposures of a stimulus display which reduce

the confounding effects of voluntary movement. Two extensive studies (Averbach & Coriell, 1961; Sperling, 1960) have explored the memory function of brief visual stimuli by the methods of partial and complete report. The result of these studies was the postulation of a visual STSS, necessary to account for the persistence of a visual image beyond its exposure duration. That is, an iconic memory exists for 1/4 of a second, after which it decays exponentially (Averbach & Coriell, 1961; Sperling, 1963; Mackworth, 1963; Smith & Carey, 1966; Eriksen & Collins, 1967; Keele & Chase, 1969; Haber & Standing, 1969; Rumelhart, 1970).

Mackworth (1962) investigated the etiology of perception distinguishing between a visual image and the memory trace. She defined the image as resulting from stimulation, while the trace resulted from a perceptual response. Recall increased linearly with stimulus duration up to 1 second. Within this range, the visual image fades before the limitations of the memory trace are reached, and as such, the image has increasingly greater significance in recall accuracy as exposure duration is reduced. At stimulus durations longer than 4 seconds, the limiting factor is the memory trace. A logarithmic relation exists for display durations, from 1/2 to 10 seconds, and the amount recalled. Mackworth (1963) concluded that: (i) the visual image persists for 1/4 seconds from which 3-4 items can be read, and (ii) there is insignificant decay in the memory trace up to 20 seconds.

Form of Iconic Information. Iconic memory is represented in terms of physical dimensions (Neisser, 1967; Posner & Keele, 1967; Dick, 1970; Efron, 1970). The factors considered relevant to iconic storage are energy variables such as: intensity, quality (contrast ratio), exposure duration, and spatial location. Further, STSS is neither associative or abstract (Wickelgren & Whitman, 1970; Wickens & Engle, 1970).

Control. A great weight of evidence exists supporting the notion that items are processed in parallel in STSS, while transfer to STM, per modality, is sequential (Mackworth, 1962; Sperling, 1963; Neisser, 1963; Novick & Lazar, 1963; Smith & Carey, 1966; Mewhort et al., 1969; Rumelhart, 1970).

Summary. Fitts & Posner (1968) comment that both the capacity and the rate of loss of information in visual STSS are high. They estimate the maximum capacity at 10 items, and a maximum duration of 1-2 seconds (Posner & Keele, 1967), with the fastest rate of loss occurring in the first 1/2 second.

Psychological Evidence for the Nature of Kinesthesis

Konorski (1967) proposed a dual control model of voluntary movement. This model is premised upon two major findings. Sensory feedback latencies to central mechanisms are too long to be in direct control of short movements

(Morgan, 1917; Lashley, 1951; Chernikoff and Taylor, 1952; Higgins and Angel, 1970). Voluntary movements seem to be preprogrammed and triggered off as a whole, so that it is impossible to 'break-in' upon a "bi-" or "poly-phasic unit" (Woodworth, 1899; Fitts, 1964).

Lashley (1951) found that a single finger can be tapped at a rate of ten strokes per second, and that the successive finger movements of a skilled pianist can be made in a definite order at about sixteen strokes per second. He concluded that higher motor centres must release unmonitored programs which have no affective sensory correlates if feedback lags are as long as 0.125 seconds. Thus, the control of muscular movement is believed to be an alternation of control of the muscles by voluntary inputs (programs) and by stabilizing K feedback.

A skilled movement of short duration may be consciously initiated and then regulated by continuous "error actuation," similar to a feedback servo-mechanism, so that S is actuated by the difference between the present and the intended final position of the 'unattended' limb (Gibbs, 1970). Welford (1968) believes that corrections made in terms of this final position would not require any new decisions. This notion is congruent with the sensory feedback implications of Fitts' Law (Fitts and Posner, 1968; Keele and Posner, 1972).

The distinction of the two components of the K system seems adequately described by Stevens' (1961) two classes of

power functions. Prothetic transducers respons in increasing numbers as stimulus intensity increases; while on a metathetic continuum, increases in stimulus magnitude cause a different population of receptors to be activated.

Wood (1969) defined active kinesthesis as "the sense of rate of self-initiated arm movement." By a process of elimination, she concluded that none of the joint receptors are responsible for active kinesthesis. The application of procaine to the joint capsule impaired passive, but not active movement (Browne, Lee and Ring, 1954; Chase, Rapin, Gilden, Sutton & Guilfoyle, 1961). Therefore, only the muscle spindles remained as the logical choice for the control of active K. Further, their operating characteristics conform to the nature of a prothetic transducer (Stevens and Stone, 1959; Stevens, 1961). Homma, Kano and Takano (1962) demonstrated that the muscle spindles are specifically sensitive to the velocity of the muscle stretch. As velocity increases, the number of units responding increases, and the rate of response of each individual unit also accelerates (Gibbs, 1954; Ruch et al., 1961; Mathews, 1964).

Summary. K appears to be the sense of limb position (location) and movement (distance). It seems to consist of two interacting components (Botelho, 1965; Howard and Templeton, 1966; Konorski, 1967; Taub and Berman, 1968; Posner and Keele, 1972). The subcortical cerebellar component is served by prothetic transducers (muscle spindles) which provide distance information and is susceptible to spontaneous decay. The conscious (sensory cortex) aspect of

[illegible]

K is mediated by the metathetic transducers in and around the joint, deep fascia, and tendons (Rose and Mountcastle, 1959), and which provide location information.

Masking and Psychological Time

The temporal sequence of stimulation and perception need not strictly correspond. By lagging behind stimulation, perception has the capacity to integrate and/or obliterate successive stimuli into psychological chuncks (Boynton, 1961; Ericksen and Collins, 1967; Stroud, 1956; White, 1963).

Backward masking is a procedure by which the effectiveness of the target stimulus (TS) is reduced by the consecutive presentation of another, the masking stimulus (MS). That is, the absolute threshold for the TS is measured with and without the MS; the difference between the two thresholds is the amount of masking. Further, masking is a technique for controlling the processing time from iconic storage into STM. Perception time or 'clearing time' of the TS is defined by the range of delays over which backward masking can be obtained.

A convergence of evidence indicates that stimulation for 100 milliseconds is registered as a separate perceptual event (Raab, 1963; Mayzner, Tresselt and Helfer, 1967; Kahneman, 1969). The duration of the visual response begins to represent the duration of the sitmulus only when the latter exceeds 100-120 milliseconds. All briefer stimuli are treated as if they were 100 milliseconds long (Kahneman, 1969). This assumption explains the dependence of several

perceptual effects on SOA, stimulus-onset-asynchrony, rather than on the duration of TS or ISI (Donchin, 1967; Kahneman, 1969). That is, when the duration of TS is varied, with ISI constant, SOA is completely confounded with TS duration. The confounding is due to the lack of identification of a critical stimulus duration: the 'on-response.' Boynton (1957, 1962) has operationally defined the 'on-response' by plotting TS threshold as a function of SOA. Exposure durations greater than this critical value, allow rehearsal actually within the stimulus presentation, while the ISI provides additional rehearsal. Even if rehearsal does not occur in ISI, _S_ is able to "pick-off" items from a decaying trace.

Backward masking results from the temporal interaction of TS and MS. Two major theories have attempted to explain the form of this interaction.

Integration theory. The 'luminance summation-contrast reduction' hypothesis holds that the energy of MS summates with that of TS to reduce the contrast of TS and lower its detectability. This view predicts maximum masking at SOA = 0; the amount of summation is inversely proportional to the delay. A monotonic function demonstrates a greater probability of detection with greater delays (Alpern, 1953; Eriksen and Hoffman, 1963; Eriksen, 1966; Eriksen and Lappin, 1967; Eriksen, and Collins and Greenspoon, 1967; Eriksen and Rohrbaugh, 1970; Spencer and Shutich, 1970; Schiller, 1968; Thompson, 1966).

<u>Interruption theory</u>. One form of this theory maintains that the percept of the TS is not formed under masking. The more prominent view holds that the decaying trace of the TS is erased before it can be read into STM. Consequently, the duration of the visual image is equated with the SOA between TS and MS. This hypothesis predicts maximum masking with delays from 20-100 milliseconds after the offset of TS. A non-monotonic masking function describes the phenomenological disappearance of TS at certain intermediate delays. Further, this theory predicts the possibility of a 'weak' mask having a maximum effect when delayed. This is based upon the assumption that it is easier to obliterate an icon after it has been partially deteriorated (Spencer and Shuntich, 1970).

<u>Summary</u>. Kahneman (1969) suggested that these two theories are not incompatible as explanations for backward masking. With an SOA $\leq$ 150 milliseconds, the TS and MS may be either integrated into a composite input, or the MS may erase the TS; while at SOA's > 150 milliseconds, processing of TS, if not already completed, is interrupted by the mask.

Eriksen and Rohraugh (1970) qualify the acceptance of the erasure interpretation on two points. At ISI's of 0-50 milliseconds, TS and MS are perceived as a composite, and not merely as the MS. Also, the erasure hypothesis is embarrassed by forward masking data; technically the MS should be erased, but it is not (Eriksen and Collins, 1965; Smith and Schiller, 1966).

In general, the shape of the masking function, as SOA increases, is a product of two processes: the increasing susceptibility of the fading trace to masking, and the increasing probability that a 'designated' element is processed by S before the mask occurs.

Coding and Pattern Detection

Redundancy. Teichner, Reilly & Sadler (1971) demonstrated that for a constant area of search, the probability of detecting a briefly exposed (visual) signal was greater, the greater the density of signals in the area.

Coding. Teichner & Sadler (1962) related coding performance to stimulus complexity. Performance decreased with increased stimulus complexity and with reduced signal detection.

Backward Masking in the Motor System

Poulton (1963) stated that the implication of a decay theory for motor memory must be considered in terms of both ungraduated and discrete displays (positions). In tracking studies, a delay (receptor-effector span) of 200 milliseconds after a 100 millisecond stimulus presentation considerably degraded performance. Discrete, unpredictable events have a 'built-in' defence against errors in immediate memory, while ungraduated events are drastically degraded even with a slight fading of the memory trace.

Sharp (1971) and Salmela (1972) demonstrated that self-initiated, discrete, K input and output does not significantly decay up to 8 and 12 movements, respectively, even with an IT. The problem here, however, was the confounding of self-initiation and discreteness.

Chase, Rapin, Gilden, Sutton & Guilfoyle (1961) used backward masking with both regular and complex pattern keytapping. Delayed sensory feedback, accomplished by masking vibrators, did not significantly alter performance on the regular (redundant) task, but did for the complex pattern task.

The K Code

Basic to the lack of understanding of K is the form of the K code. In an attempt to define this code, Wilberg and his associates have investigated the independent variables of direction of replacement, ballistic pressure changes, constant weight loads, distance and constant torque in the STM paradigm (Carre, 1969; Hughes, 1969; McClements, 1969; Moyst, 1969: Wilberg, 1969).

Using the IT paradigm, Posner & Konick (1966) investigated the differential reliance of visual and K information on central processing capacity. Visual-location information did not deteriorate with an unfilled interval, but with interference the rate of forgetting was a function of the amount of processing capacity available during the interval (Posner & Rossman, 1965). K-distance information deteriorated with an unfilled interval but the rate of forgetting was not a function of IT difficulty (Adams &

Dijkstra, 1966)

Extending Posner's (1967a) attempt to identify visual and K codes, Labbs (1971) demonstrated that recall with reliable K-location cues showed similar interference effects as rehearsalbe. visual-location cues. K-distance cues were unaffected by interference.

To further qualify the temporal immunity of K to central processing, performance after 15 seconds delay has been demonstrated as equal to that after zero seconds delay (Adams & Dijkstra, 1966; Stelmack 1969). On the criterion of decay and repetition (Adams & Dijkstra, 1966; Stelmack, 1969, 1971; Salmela, 1972), and both verbal (Posner & Rossman, 1965; Posner & Konick, 1966; Posner, 1967a) and non-verbal ITs (Williams et al., 1969; Patrick, 1971; Sharp, 1971), the K sense has not demonstrated any appreciable decrement in recall due to a lack of central processing capacity for the initial 15-20 seconds following the criterion presentation.

There exists in the literature an uncertainty of the psychological manifestation of the prothetic and metathetic transducers. It appears that two conclusions can be drawn from the research. One, Wilberg (1969) has suggested that K is undecodable and is therefore a function of a pre-wired system. The other logical possibility is that the STM paradigm is insensitive to the coding dimension of K.

The avenue of this research was to extend the former possibility by the use of a hopefully, more sensitive experimental design which would only consider location cues.

CHAPTER III

METHODS AND PROCEDURES

On the basis of the review of literature, certain measureable properties may exist for a K sensory register. The variables selected in this experiment were contingent upon the findings from studies on motor STM (e.g. distance and location cues), stimulus detection, and coding, in conjunction with the backward masking paradigm. The levels of these variables (stimulus exposure and stimulus complexity) were determined by the structural limitations of the hand and the experimental apparatus.

Subjects

Eight male _S_'s, ages 23 to 45, were used in Experiment I and II, while six of these same subjects, ages 24 to 28 were used in Experiments III and IV. All _S_'s wrote with their right hand.

Independent Variables

Test Patterns. The stimuli were patterned templates made of 4 inch by 6 inch by 1/8 inch tempered masonite. These patterns functioned to displace each finger to one of three levels: zero (0), 1 centimetre (1), or 2 centimetres (2). The various templates used in each experiment were appropriately coded and can be seen in Appendix A.

<u>Presentation Time</u>. The following stimulus durations were used: 1000, 500, 250, 100, and 50 milliseconds.

<u>Masking</u>. A masking stimulus was presented for 1 second by means of a 4 lobe cam having a 1 5/8 inch lift. The cam was driven by a 1/4 H. P. motor (1725 RPM) with a 1 to 12 reduction. The cam arrangement can be seen in Figure 3.

<u>Dependent Variables</u>

Eight dependent variables were used to describe performance, seven of which were error scores.

1. Correct - <u>S</u> did not make any errors.

2. S/L - <u>S</u> produced an error by responding with a short movement when a long movement was indicated.

3. L/S - <u>S</u> produced an error by responding with a long movement when a short movement was indicated.

4. S/N - <u>S</u> produced an error by inventing a short movement when no movement was indicated.

5. N/S - <u>S</u> produced an error by omitting a short movement when it was indicated.

6. L/N - <u>S</u> produced an error by inventing a long movement when no movement was indicated.

7. N/L - <u>S</u> produced an error by omitting a long movement when it was indicated.

8. Total number of errors.

Apparatus

The stimulus patterns were presented to S by using the apparatus pictured in Figures 2 and 3. The legend for abbreviations used in these figures follows:

FH - Finger Holders

BD - Blocking Device

SA - Switch A

SB - Switch B

SC - Switch C

ST - Stimulus Template

NT - Neutral Template

C - Carriage

TA - Timer A

TB - Timer B

S1 - Push Solenoid

S2 - Pull Solenoid

R - Recorder

P - Pens (4)

M - Motor

CM - Cam

R1 - Relay 1

R2 - Relay 2

Experimental Design

The experimental design adopted for this set of 4 investigations was treatments by Ss, factorial, with replications. The independent variables (IV) were considered fixed and were treated so in the primary analysis. Subjects

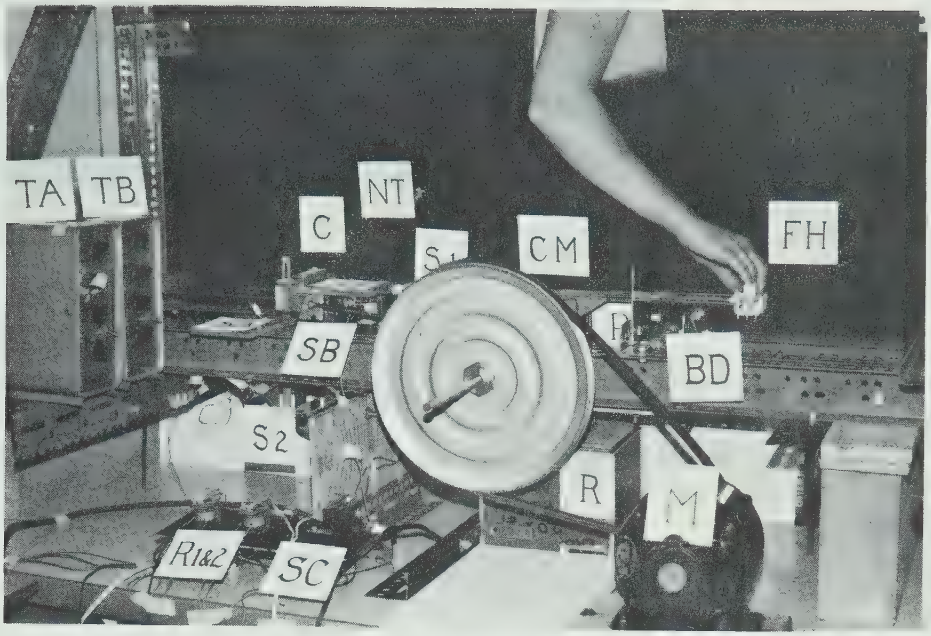


FIGURE 2 - SIDE VIEW OF APPARATUS

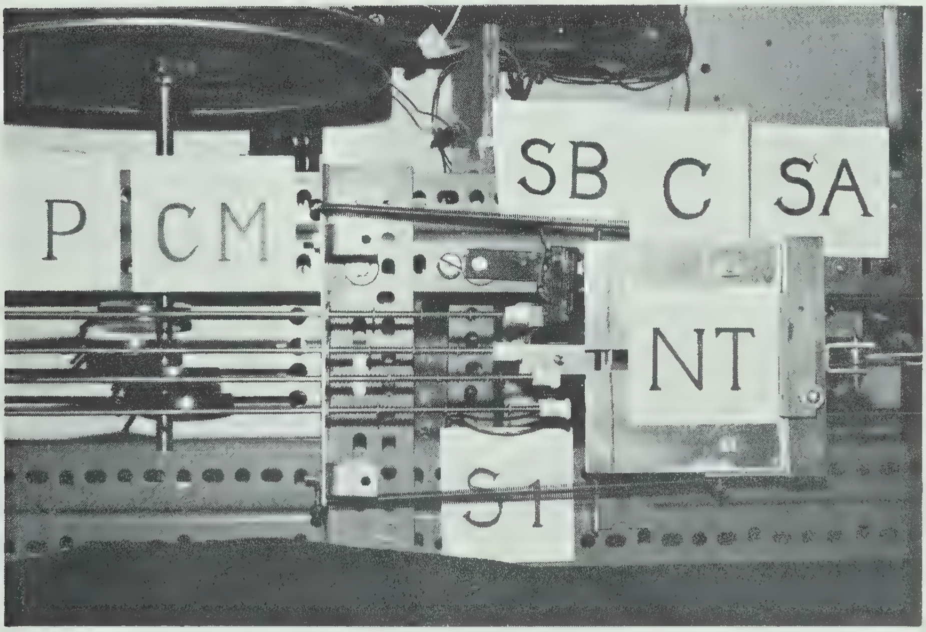


FIGURE 3 - TOP VIEW OF APPARATUS

and replications, when analyzed as IVs in the secondary analysis, were considered random. The purpose of including the secondary analysis was to determine whether or not the Ss performance on all 8 DVs were similar; particularly as a function of trials.

Experiment I and II

The following design indicates the exploratory approach of E to the experimental question.

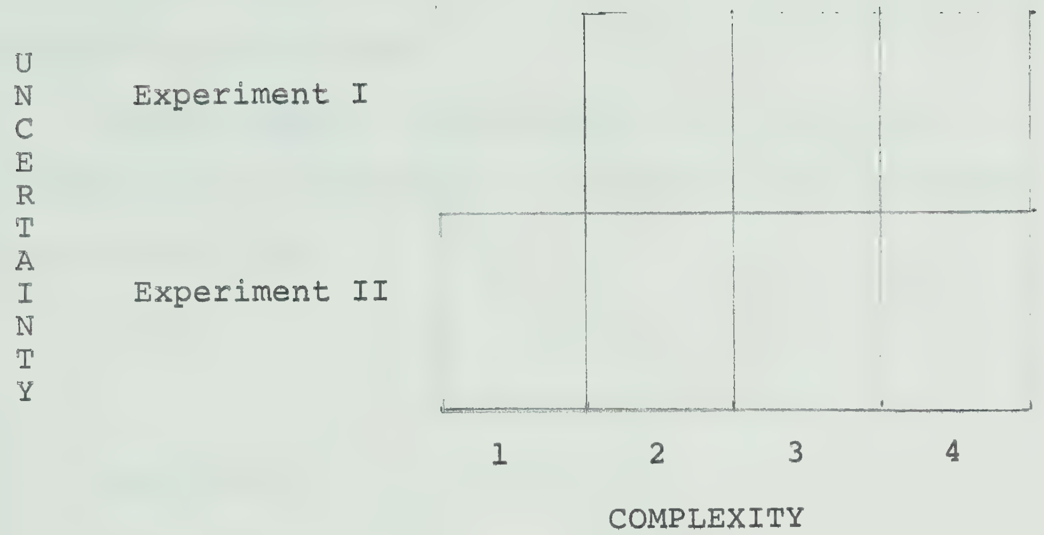
UNCERTAINTY

COMPLEXITY	Experiment I		Experiment II	
	500	1000	500	1000
1	X	X		X
2				X
3				X
4				X

DURATION (msec)

Legend X indicates the incompleteness of the design.

From this initial approach, the following design was formed.

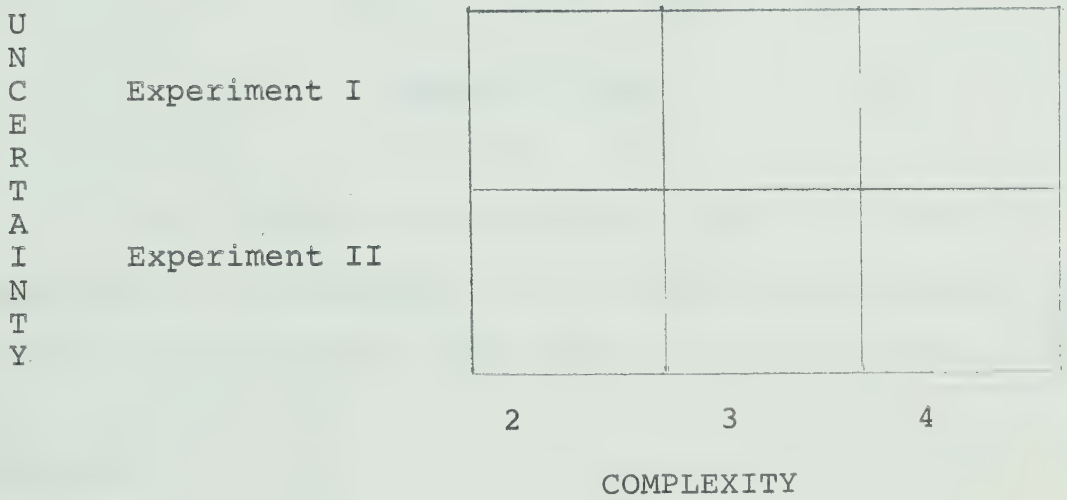


Eight Ss were involved with the data taken from the single replication at 500 milliseconds of Experiment I and the second replication at 500 milliseconds of Experiment II. In order to gain equal observations across the complexity factor, only the first 16 stimuli per complexity level were used in the analysis. Consequently, 8 2-finger and 2 3-finger stimuli were not incorporated in the analysis. This decision seemed justified due to the fact that the majority of these stimuli were 2-finger patterns, consisting of the third and fourth fingers. During a pilot study, the fourth finger produced a consistent ommission (N/S) error in the "known," 3- and 4-finger patterns, indicating its insensitivity in the

more complex patterns. Further, the use of these 'additional' stimuli appeared to optimize the uncertainty condition for each complexity level.

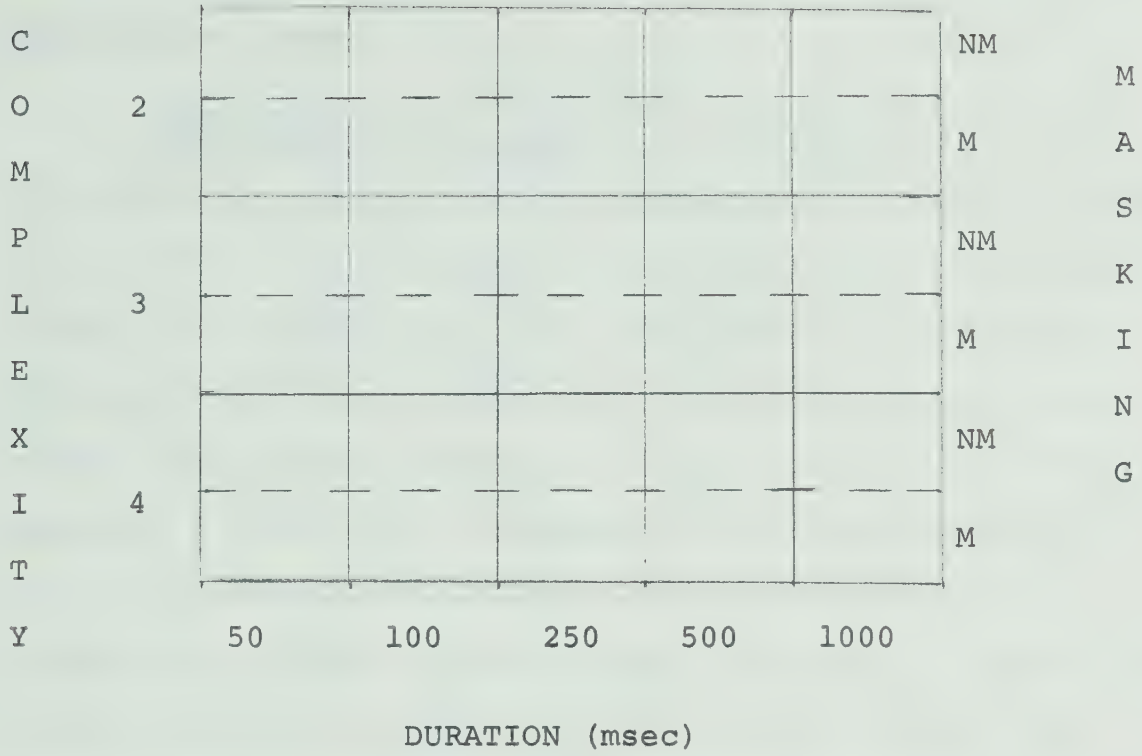
Due to the unequal set uncertainty between Experiments I and II, raw scores were not comparable, and were therefore converted to percentages.

Taken together, Experiments I and II formed a 2 x 3 x 8 (Uncertainty x Complexity x Subjects Trials) design, with 128 entries per cell.



Experiment III and IV

The experimental design was a 2 x 5 x 3 factorial deisgn with 2 replications. There were 6 trials per level of complexity and 6 Ss; this gave 72 observations per cell.



Set uncertainty was equal across all levels of complexity. Consequently, raw scores were comparable, and were not converted to percentages, as in Experiment I and II.

Procedure

General. S sat in a chair with his right arm through a partition which prevented him from observing the displacement of this fingers. His four fingers were placed within the holders (FH) fastened to the end of the displacing rods (Figure 2). S was instructed to keep his fingers and wrist relaxed. Prior to Experiments I, and IV, five practice trials were given to each S in order to familiarize him with the testing procedure and with the task of discriminating

among nil, short, and long movements for the different presentation times.

Experiment I, II, and III. To begin each trial, E elevated a blocking device (BD) immediately behind the finger holders (FH). The function of this device was to hold S's fingers in a neutral position (equivalent to the neutral template) while the carriage (C) was being retracted and loaded. Because the stimulus was longer than the neutral template, it effected the removal of the blocking device, which dropped free with gravity during the stimulus presentation. After retracting the carriage to a point just forward of switch A (SA), E set a stimulus template (ST) upon the neutral template (NT), which was mounted on the carriage.

At this point, S was given the command "Ready." Immediately after this command, E released the spring-loaded carriage, which was swiftly drawn against switch B (SB). This switch initiated the duration of the presentation time of the stimulus by means of a Hunter Decade Interval Timer (TA). For the stimulus duration, S's fingers were differentially displaced by the force of the template-loaded carriage, which was transmitted through the rods to the finger holders. After the stimulus interval, a second Hunter Decade Interval timer (TB) energized a push solenoid (S1) (18P-1-120V-60HZ) to release the stimulus template from the carriage. E caught the template, then moved the chart recording paper approximately 0.5 centimetres, by means of

switch C (SC), and gave S the command "Recall." Once the template was released from the carriage the spring loaded rods returned to the position against the neutral template. Therefore, the acquisition of stimulus information was passive, while recall was active. Test stimuli and responses were recorded on a Mosely 680 Strip Chart Recorder (R) by four, spring-loaded pens (P) mounted at right angles to the displacing rods.

In Experiment I, E told S which and how many fingers were to be involved, but did not do so in the remaining three experiments. The purpose of Experiments I (certainty condition) and II (uncertainty condition) was to gain a measure of man's ability to detect and recognize kinesthetic finger patterns. This was accomplished by comparing S's performance when recalling a known 2-finger pattern (Experiment I) with that same pattern when not forewarned by E (as in Experiment II). Further, each 2 and 3 finger pattern could be considered for both the known condition, and the same known condition, plus 1 and 2 additional components (finger movements), in Experiment I.

Experiment IV. Essentially the same procedure was followed in Experiment IV, except that immediately after the stimulus presentation, a 1 second masking stimulus occurred. Figure 4 illustrates the temporal arrangement of the 5 masking conditions. The masking stimulus began at stimulus onset in order to compensate for the inertia within the masking system. However, masking was not effective until the end of the

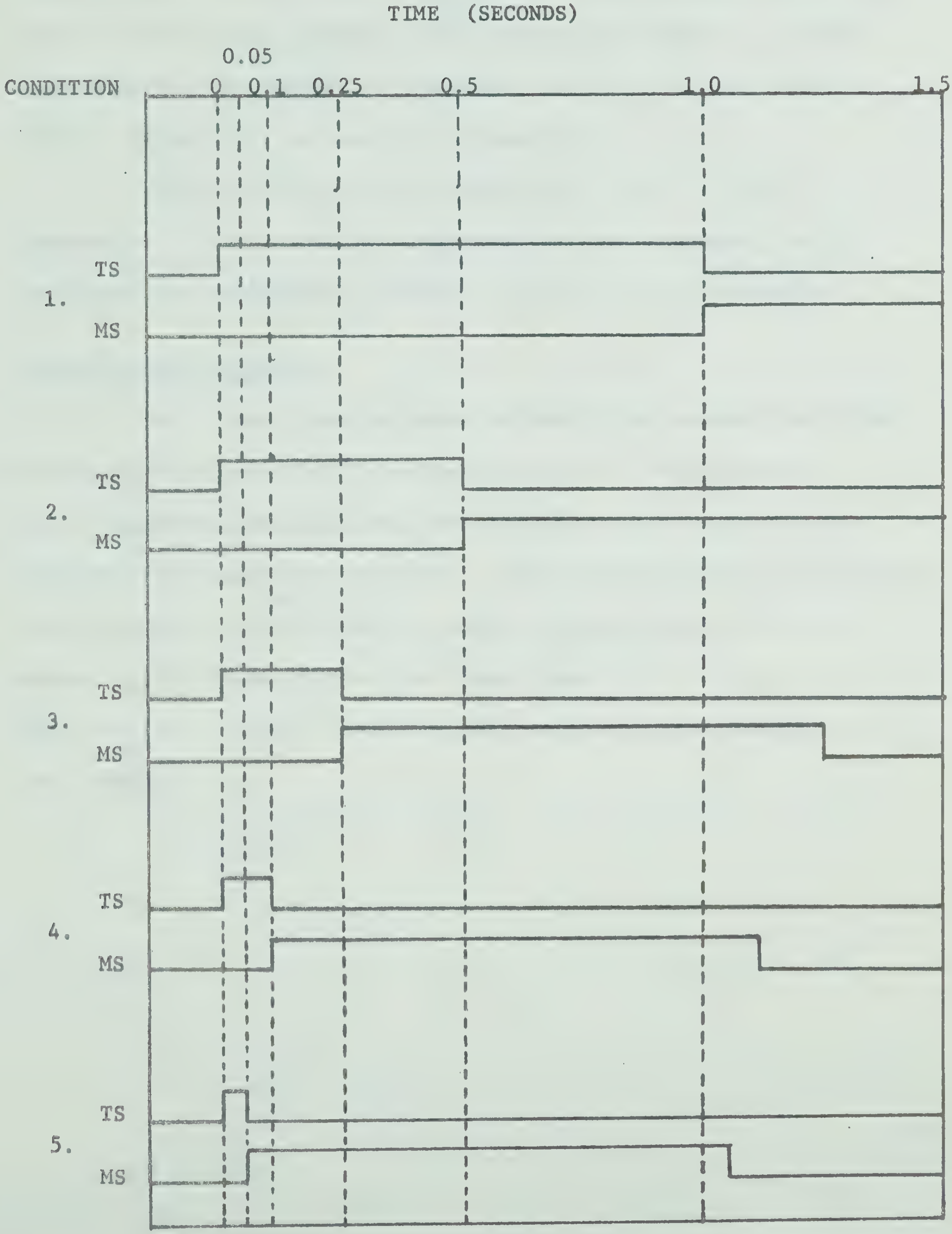


FIGURE 4 - The Five Conditions of Masking

TS= Target Stimulus duration
MS = Masking Stimulus duration

stimulus presentation time ($\Delta t = 0$) when a pull solenoid (S2) withdrew the carriage and template, allowing the cam lobes (CM) to come into contact with the pen holders. As the carriage was withdrawn, it opened switch A which ended a trial, after the one second of masking.

The purpose of Experiments III and IV was to determine if K- location information was susceptible to masking, and therefore whether or not it was codeable.

Statistical Analysis

The method and procedure described above furnished 8 dependent variables from each of the 4 experiments. In all instances the data was subjected to the appropriate analysis of variance (Anova). That analysis was followed by the calculation of F-ratios and a Newman-Keul's test on means. The alpha rejection level used for interpretation was $\alpha = .01$. Other levels shown were for the benefit of the reader.

CHAPTER IV

ANALYSIS

The analysis of the four experiments may be conceptualized into: (i) man's ability to detect K finger patterns under two conditions of uncertainty, and (ii) his ability to detect such patterns under the limitations of stimulus duration and masking. It appeared necessary to first investigate how man perceived K finger patterns. An understanding of how man operated on redundant ("certain") and "uncertain" K stimulation provided a bench march against which appropriate comparisons were allowable with the masking condition.

Experiments I and II

Hypotheses

> H_1: Performance (DV = 1....8) for known K finger patterns = Performance for unknown K finger patterns.

In the first hypothesis, it was proposed that performance for known and unknown K finger patterns, was equally good.

> H_2: Performance (DV = 1....8) for known 2-, 3-, and 4-finger patterns = Performance for unknown 2-, 3-, and 4-finger patterns, respectively.

Hypothesis 2 was formulated to demonstrate that K pattern detection for a known 2-finger pattern was as good as that of an unknown 2-finger pattern. Further, 3- and 4-finger

pattern detection performance was considered equal on the two conditions of uncertainty.

H_3: Performance (DV = 1....8) for Subject 1 = ... = Performance for Subject 8.

In the third hypothesis, it was suggested that all Ss performed equally well on all DVs.

Results

Preliminary Analysis: One 3-way Anova was carried out upon the eight DVs of the 2 x 3 x 8 (Uncertainty x Complexity x Subjects/Trial) design (Appendix B, Tables XVI to XXIII).

Hypothesis 1 was rejected on DV = 1, 4, 5, 6, 7, and 8 at the .01 level of confidence (Table I). The means of the eight DVs are graphed in Figure 5. At a 500 millisecond stimulus duration, Hypothesis 1 was accepted on DV =2 and 3, which may be considered simple discrimination errors. However, in terms of ommission and invention errors (DV = 4, 5, 6, and 7), and DV = 1 and 8 (both of these being gross performance scores), K pattern detection ability seems to be extremely crude. That is, in uncertainty, S invents and omits responses. But, within some range of information loading (to be considered next), his actual discrimination between two events (short and long) is the same for certain and uncertain sets.

Hypothesis 2 was rejected on DV = 1, 2, 4, 6, 7, and 8 at the .01 level of confidence (Table II). In Figure 6 the means for the eight DVs are graphed, while in Table III the significant differences between the means are summarized.

TABLE I

SUMMARY OF THREE-WAY ANOVA FOR STIMULUS UNCERTAINTY ON EIGHT DVs, EXPERIMENTS I AND II

DV	Sum of Squares	df	Mean Square	F
1	1313	1	1312.52	42.53**
2	65	1	65.33	4.46*
3	5	1	4.69	0.35
4	192	1	192.00	28.38**
5	721	1	720.75	48.68**
6	4	1	3.52	12.20**
7	4	1	4.08	9.09**
8	1302	1	1302.08	41.81**

TABLE II

SUMMARY OF THREE-WAY ANOVA FOR STIMULUS COMPLEXITY ON EIGHT DVs, EXPERIMENTS I AND II

DV	Sum of Squares	df	Mean Square	F
1	630	2	315.15	10.21**
2	309	2	154.75	10.57**
3	38	2	19.19	1.42
4	128	2	63.81	9.43**
5	154	2	77.15	5.21*
6	4	2	2.15	7.43**
7	8	2	3.94	8.76**
8	621	2	310.69	9.98**

TABLE III

SUMMARY OF SIGNIFICANT DIFFERENCES BETWEEN MEANS AS DETERMINED BY THE NEWMAN-KEUL'S METHOD, EXPERIMENTS I AND II

Summarized from Table XXV of Appendix B

DV	COMPLEXITY		
1	4	3	2
2	2	3	4
4	4	3	2
6	4	3	2
7	2	3	4
8	2	3	4

Legend - DV	Description	
1	Total Number of Correct	
2	S/L	Simple Discrimination
3	L/S	
4	S/N	Invention
6	L/N	
5	N/S	Ommission
7	N/L	
8	Total Number of Errors	

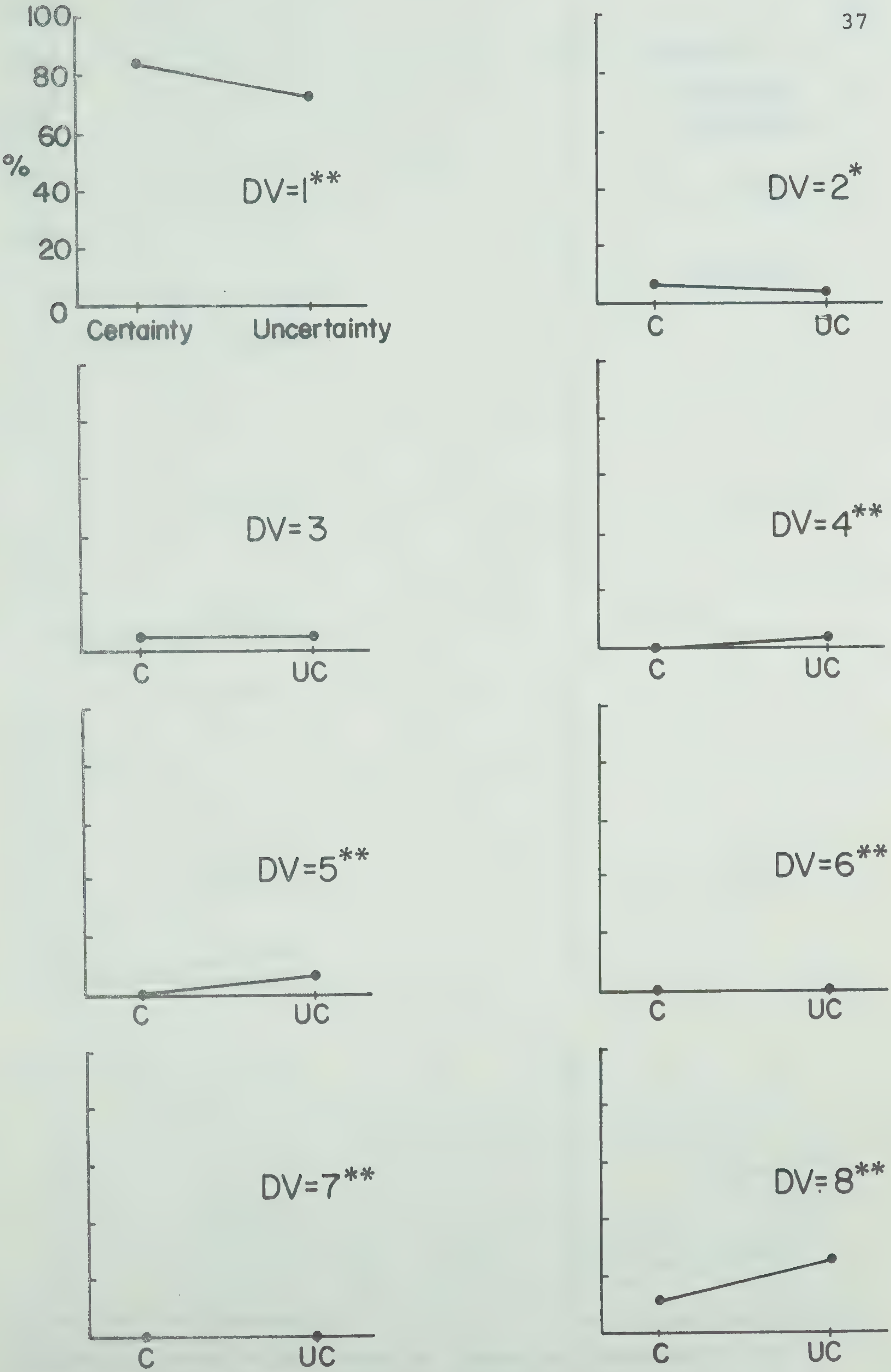


FIGURE 5 - Profile of Means of Stimulus Uncertainty for Experiments I and II

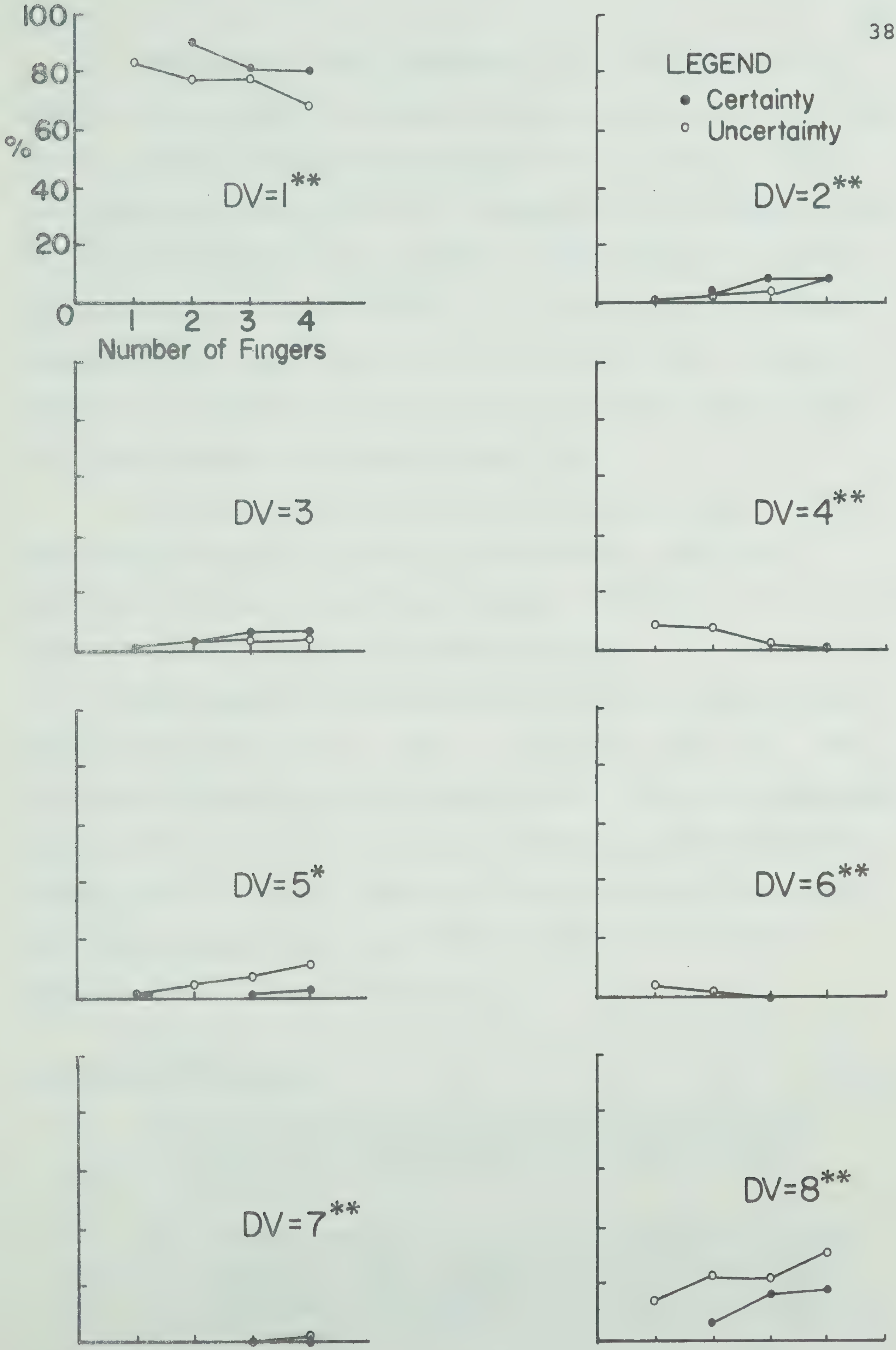


FIGURE 6 - Profile of Means of Stimulus Complexity for 3-Way Anova of Experiments I and II

Hypothesis 2 was rejected on the two transmission scores, DV = 1 and 8; on the one simple discrimination score, DV = 2; on the two invention scores, DV = 4 and 6; and on one ommission score, DV = 7. The general performance scores of 1 and 8, and the two invention scores seem to indicate S's strategy. In uncertainty, S is more likely to invent responses if the set uncertainty is too high. Except for DV = 7, levels of complexity (information loads) were all significantly different (Table III).

Although 1-finger patterns were not compared under the two conditions of Stimulus Uncertainty, they were included in Figure 6, in the "unknown" condition, as a matter of convenience, economy and meaningfulness.

Hypothesis 3 was rejected at the .01 level of confidence for DV = 1, 2, 3, and 8 (refer to Table IV). The difference between Ss was significant on the two transmission scores, DV = 1 and 8, and on the two simple discrimination scores, DV = 2 and 3. However, in uncertainty, across the four information loads, Ss both invented and omitted responses in a similar fashion.

Stimulus Complexity

H_4: Performance (DV = 1...8) for known 2-finger patterns = Performance for known 3-finger patterns = Performance for known 4-finger patterns.

H_5: Performance (DV = 1...8) for unknown 1-finger patterns = Performance for unknown 2-finger patterns = Performance for unknown 3-finger patterns = Performance for unknown 4-finger patterns.

TABLE IV

SUMMARY OF THREE-WAY ANOVA FOR SUBJECTS

ON EIGHT DVs, EXPERIMENTS I AND II

DV	Sum of Squares	df	Mean Squares	f
1	958	7	136.88	4.44**
2	1400	7	200.00	13.66**
3	850	7	121.43	8.99**
4	85	7	12.10	1.79
5	184	7	26.24	1.77
6	3	7	0.38	1.31
7	9	7	1.23	2.73*
8	961	7	137.32	4.41**

In Hypothesis 4, it was suggested that known K pattern detection was equally good for all levels of stimulus complexity, while in Hypothesis 5, unknown K pattern detection was considered equally good for all levels of stimulus complexity.

Hypothesis 4 was accepted on all eight DVs at the .01 level of confidence (Table V). In Figure 7 the differences between means are illustrated. It seemed warranted to conclude that with the appropriate 'set' of how complex (the number of fingers) the stimulus was, S could discriminate equally well for all levels of stimulus complexity.

Hypothesis 5 was rejected on DV = 1, 4, 5, 7, and 8

TABLE V

ONE-WAY ANOVA FOR COMPLEXITY, EXPERIMENT I

DV	Source	Sum of Squares	df	Mean Square	F
1	Complexity	477	2	238.29	3.58*
	Error	1399	21	66.63	
2	Complexity	111	2	55.54	1.34
	Error	872	21	41.53	
3	Complexity	78	2	39.12	1.27
	Error	648	21	30.87	
4	No Data				
5	Complexity	22	2	10.79	1.01
	Error	224.37	21	10.68	
6	No Data				
7	Complexity	0.33	2	0.17	1.00
	Error	3.50	21	0.17	
8	Complexity	477	2	238.29	3.58*
	Error	1399	21	66.63	

Legend - *.05 level of confidence

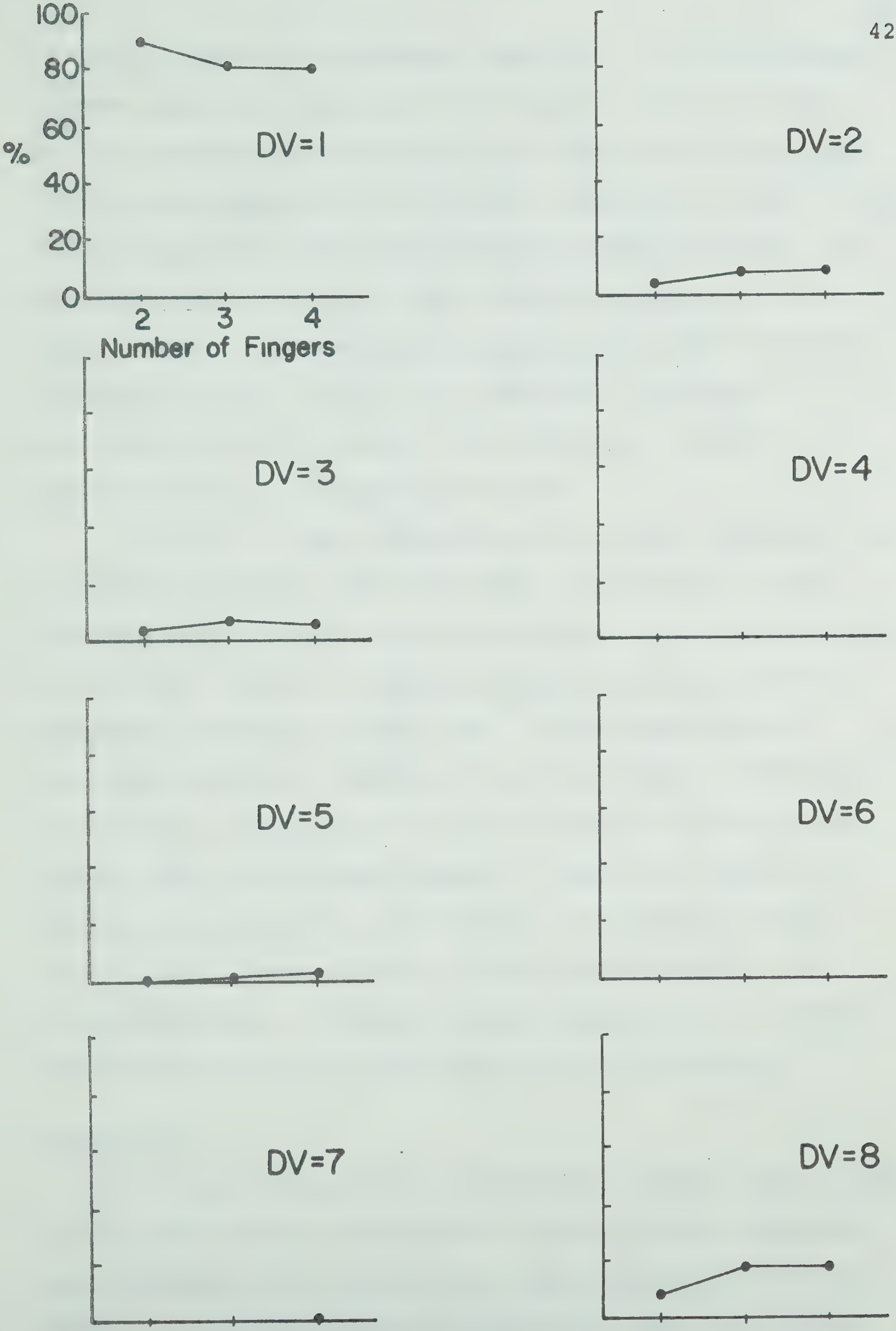


FIGURE 7 - Profile of Complexity Means, Experiment I

at the .01 level of confidence (Table VI). The differences between means are illustrated in Figure 8, while in Table VII the significant differences are summarized. From Table VII it would appear that the medium information loads (2- and 3-finger patterns) were not different from each other, but were different from the 1- and 4-finger patterns, on DV = 1 and 8. Thus, in uncertainty, S operates at three different information loads, while in the certainty condition, S perceives only one loading. The difference, therefore, appears to lay in the appropriate set.

For DV = 5 (not responding for a short movement), all information loadings were different. This form of error probably underlies the entire experiment, as it was a product of both the 'noise' in the presentation procedure and the anatomical structure of the hand. In any presentation involving either the second or the third finger, independent of the other, there was a 'carrying effect' of the unmoved finger, due to the common tendon of these two fingers. Further, in uncertainty, invention and ommission errors (DV = 4 and 7) were similar for the low loads of 1- and 2-finger patterns. However, as the stimulus load increased, these forms of errors became significantly different.

Discussion

On the two most gross performance scores (DV = 1 and 8), the main effects of Stimulus Uncertainty and Complexity were significant in spite of the significant Subjects main effect. Significant Subject interactions were not present.

TABLE VI

ONE-WAY ANOVA FOR COMPLEXITY, EXPERIMENT II

DV	Source	Sum of Squares	df	Mean Square	F
1	Complexity	964	3	321.33	4.40**
	Error	2043	28	72.98	
2	Complexity	366	3	122.03	2.99*
	Error	1143	28	40.83	
3	Complexity	74	3	24.75	1.17
	Error	591	28	21.12	
4	Complexity	462	3	154.11	6.03**
	Error	716	28	25.56	
5	Complexity	571	3	190.42	8.73**
	Error	611	28	21.81	
6	Complexity	26	3	8.70	3.75*
	Error	65	28	2.32	
7	Complexity	14	3	4.75	4.79**
	Error	28	28	0.99	
8	Complexity	948	3	316.03	4.33**
	Error	2042	28	72.93	

Legend - *.05 level of confidence
**.01 level of confidence

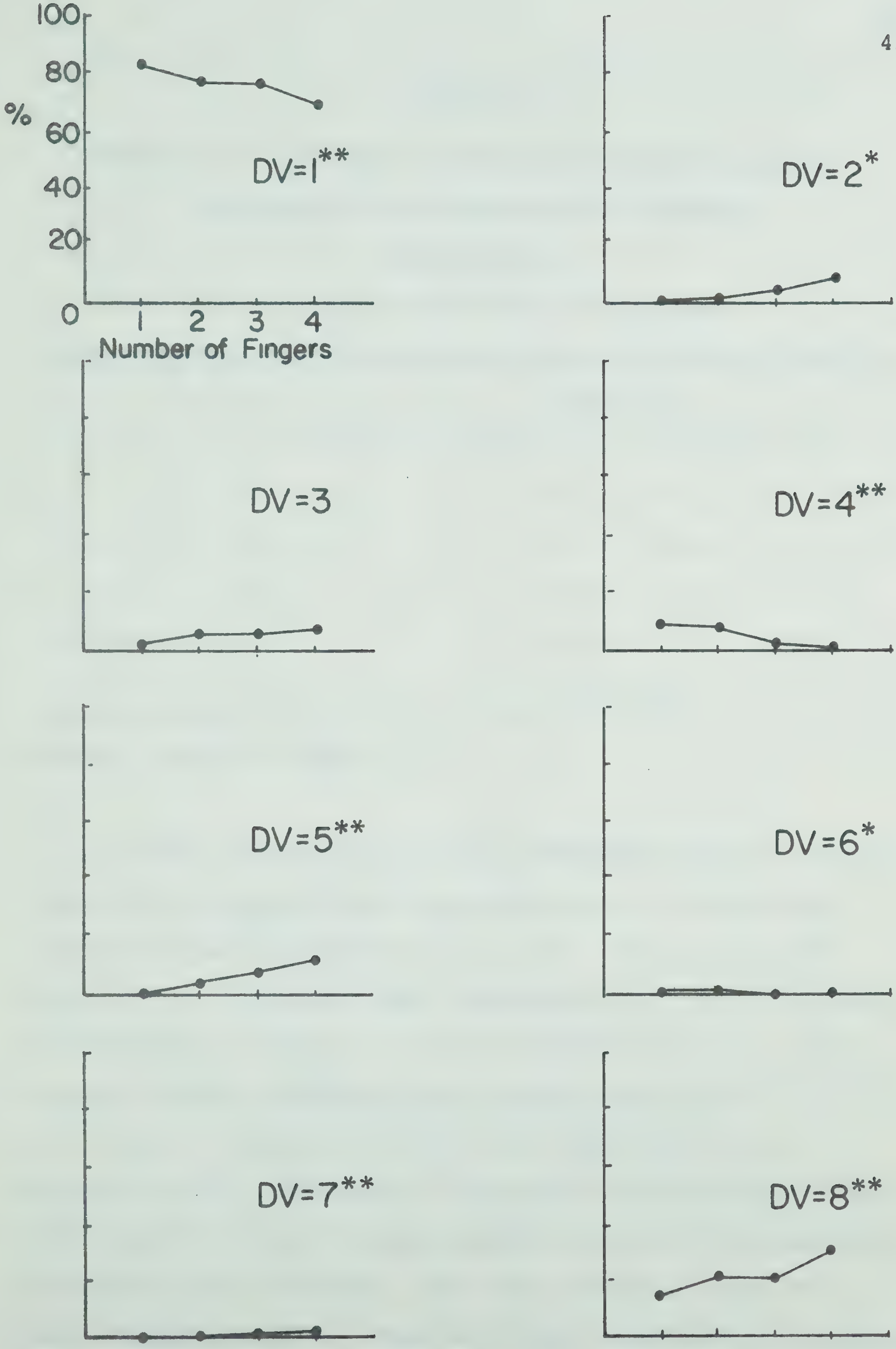


FIGURE 8 - Profile of Means of Stimulus Complexity, Experiment II

TABLE VII

SUMMARY OF SIGNIFICANT DIFFERENCES BETWEEN MEANS AS DETERMINED BY THE NEWMAN-KEUL'S METHOD

EXPERIMENT II

Summarized from Table XXX of Appendix D

DV	Complexity			
1	4	2	3	1
4	4	3	2	1
5	1	2	3	4
7	1	2	3	4
8	1	3	2	4

Legend - refer to Table 3.

The interpretation of the secondary analysis suggests that with an appropriate "set uncertainty," stimulus complexity was not significant on any DV. That is, *S* could discriminate K patterns when forewarned by *E* as to the level of complexity. However, with an "inappropriate set uncertainty" stimulus complexity was significant on DV = 1, 4, 5, 6, 7, and 8. In this situation, *S*'s performance was degraded by the inclusion of inventions and ommissions. For DV = 1 and 8, 2- and 3-finger patterns were not significantly different, while together, they were different from the 1- and 4-finger patterns. That is, under uncertainty, *S* operates

at three information loadings which appear to be contingent upon set uncertainty. With the uncertainty of which two of four fingers were moved, and to which location (short or long), set uncertainty appears to be an inverse function of the actual stimulus event. As stimulus complexity increases, this relationship tends to reverse to a 1:1 ratio. That is, S probably operates by allowing for the maximum event uncertainty, prior to stimulus presentation; consequently his power of discrimination is affected more per event, in the 2-finger task than the 4-finger task. This finding seems axiomatic of the fact that for a constant area of search, the probability of detecting a briefly exposed signal is greater, the greater the density of the different signals in the area (Tiechner and Sadler, 1962).

Experiments III and IV

Hypotheses

H_6: Unmasked performance (DV = 1....8) = Masked performance.

In the sixth hypothesis, performance was considered equal in the maksing and non-masking conditions.

H_7: Performance (DV = 1....8) at a stimulus duration of 1000 milliseconds = ... = Performance at a stimulus duration of 50 milliseconds.

In the seventh hypothesis, it was held that performance was equal for all stimulus durations (1000, 500, 250, 100, and 50 milliseconds).

H_8: Performance (DV = 1....8) for 2-finger K patterns = Performance for 3-finger patterns = Performance for 4-finger patterns.

The eighth hypothesis was formed to demonstrate that performance was equal for all levels of stimulus complexity.

Results

Preliminary Analysis: One 3-way Anova was carried out on the eight DVs (Appendix E, Tables XXXI to XXXVIII). The main effects of Masking, Duration, and Complexity are summarized in Tables VIII, IX and X, respectively. Significant interactions are shown in Table XI.

From Table VIII, Masking appeared to demonstrate significance on the DVs = 1, 3, 4, 5, and 8. There does not seem to be any specific trend in the form of the errors committed; simple discriminations, inventions, and ommissions were all present. It would appear from Table IX that Duration errors tend to be simple discriminations (DV = 2 and 3). Further, the Complexity factor appears to be significant on all eight DVs. Tentatively, hypotheses 6, 7, and 8 were rejected. However, it was evident from Table XI that Masking interacted with both Duration, and Complexity.

Figures 9 and 10 geometrically illustrate the AB (Masking x Duration) and AC (Masking x Complexity) interactions. It should be noted that DVs 1 and 8 are reciprocal scores, and therefore only the former was statistically analyzed.

Secondary Analysis: An analysis of the simple main

TABLE VIII

SUMMARY OF THE THREE-WAY ANOVA FOR MASKING

EXPERIMENTS III AND IV

DV	Sum of Squares	df	Mean Square	f
1	41	1	41.39	44.53**
2	1	1	1.16	3.64*
3	8	1	7.70	35.01**
4	28	1	28.02	325.36**
5	10	1	10.00	35.84**
6	0	1	0.11	4.99*
7	0	1	0.17	2.38
8	47	1	47.11	51.75**

TABLE IX

SUMMARY OF THE THREE-WAY ANOVA FOR DURATION

EXPERIMENTS III AND IV

DV	Sum of Squares	df	Mean Square	f
1	40	4	10.06	10.82**
2	13	4	3.30	10.40**
3	7	4	1.82	8.28**
4	1	4	0.24	2.78*
5	3	4	0.64	2.32*
6	0	4	0.04	1.83
7	0	4	0.02	0.26
8	43	4	10.79	11.85**

TABLE X

SUMMARY OF THE THREE-WAY ANOVA FOR COMPLEXITY

EXPERIMENTS III AND IV

DV	Sum of Squares	df	Mean Square	F
1	220	2	109.76	118.00**
2	69	2	34.40	108.31**
3	6	2	3.08	13.99**
4	36	2	18.06	209.72**
5	58	2	29.07	104.14**
6	1	2	0.55	23.08**
7	9	2	4.55	64.94**
8	216	2	107.76	118.38**

TABLE XI

SUMMARY OF SIGNIFICANT INTERACTIONS OF THE THREE-WAY ANOVA

Summarized from Tables XXXI to XXXVIII Appendix E

DV	AB	AC	BC	ABC
1	.01	.01	--	--
2	--	--	--	--
3	--	--	--	--
4	Insufficient Data			
5	--	.01	--	--
6	--	.01	.05	--
7	.05	.05	--	--
8	.01	.01	--	--

effects was performed upon the AB and AC interactions in order to determine, at which levels of factor B and C, Masking (A) was effective.

Masking x Duration (AB) Interaction

H_9: $\sigma^2_{\alpha\beta} = 0$

Hypothesis 9 was formulated to demonstrate that there was zero interaction between Masking (A) and Duration (B), for DV = 1....8. It was accepted on all specific error scores (DV = 2...7), but rejected on DV = 1 and 8 (Table XI).

The AB interaction was not significant on any of the specific error scores (DV = 2....7). This finding appeared to lend evidence that K information was not susceptible to rehearsable errors, and was therefore not codable.

Discussion

The analysis of the simple main effects of A on B (Table XII) revealed that masking (A) was significant for $b_2 - b_5$ (500, 250, 100, and 50 milliseconds). This analysis is illustrated in Figure 9a and 9b. Levels of A have been separated in Figure 10, so that the AB interaction can be seen over factor C.

The Ss appeared to transmit K information at a constant rate for all unmasked stimulus durations (Table XLI, Appendix E). However, with masking, K pattern detection can be significantly reduced at stimulus durations < 500 milliseconds. This may be summarized as:

50 100 250 500 1000

TABLE XII

ANOVA OF THE SIMPLE MAIN EFFECTS OF A ON B

DV = 1

Source	Sum of Squares	df	Mean Square	F
A for b_1	1	1	1.08	1.16
A for b_2	10	1	9.72	10.45**
A for b_3	140	1	140.43	151.00**
A for b_4	108	1	108.00	116.13**
A for b_5	290	1	290.42	312.42**
Within Cell	1980	2130	0.93	

Note: $F_{.99}$ (1,2130) for α = .01 is 6.63

The null hypothesis of homogeneity of variance for factor A at b_2, b_3, b_4, and b_5 was rejected at the .01 level of confidence, while it was accepted for factor A at b_1. That is, masking significantly deteriorated performance for stimulus presentations < 1000 milliseconds.

TABLE XIII

ANOVA OF THE SIMPLE MAIN EFFECTS OF B ON A

DV = 1

Source	Sum of Squares	df	Mean Square	F
B for a_1	21	4	5.26	5.67**
B for a_2	518	4	129.45	139.19**
Within Cell	1980	2130	0.93	

Note: $F_{.99}$ (4,2130) for α = .01 is 3.32

It was tentatively concluded that all of the simple main effects of B on A were significant at the .01 level of confidence. However, the Newman-Keul's test between means (Table XLI, Appendix E) revealed no significant differences between the means for B on a_1.

That is, as masked presentation time is increased form 50 through to 250 milliseconds, S gained no new information. Further, performance for masked presentations of 500 to 1000 milliseconds was not significantly different.

Logically, it would seem that if K were codable, then it would be rehearsable. The property of rehearsability, then, would make K information a function of stimulus exposure time, which, in this experiment, was controlled by masking. It would be expected that a longer stimulus would lead to greater accuracy, since a greater duration allows S more search time and opportunity to check his initial evaluation of the signal's identity (Tiechner & Olson, 1971).

If K were codable, then increases in stimulus duration would improve performance by allowing S to rehearse. This was not found. That is, unmasked stimulus presentations were not a function of stimulus duration (Figures 9 and 10). Therefore, K appears to be uncodable. However, this conclusion was only tentative. The absence of a significant Non-Masking x Duration interaction may simply mean that the stimulus durations used in this study were in excess of a critical reception time of K information in STSS.

The method of backward masking, allowed E to control S's sampling time of the TS. The secondary analysis indicated that masked durations < 1000 milliseconds significantly degraded K pattern detection. This fact suggested that K was codable. However, perforamnce on all unmasked durations was not significantly different, and further, all masked

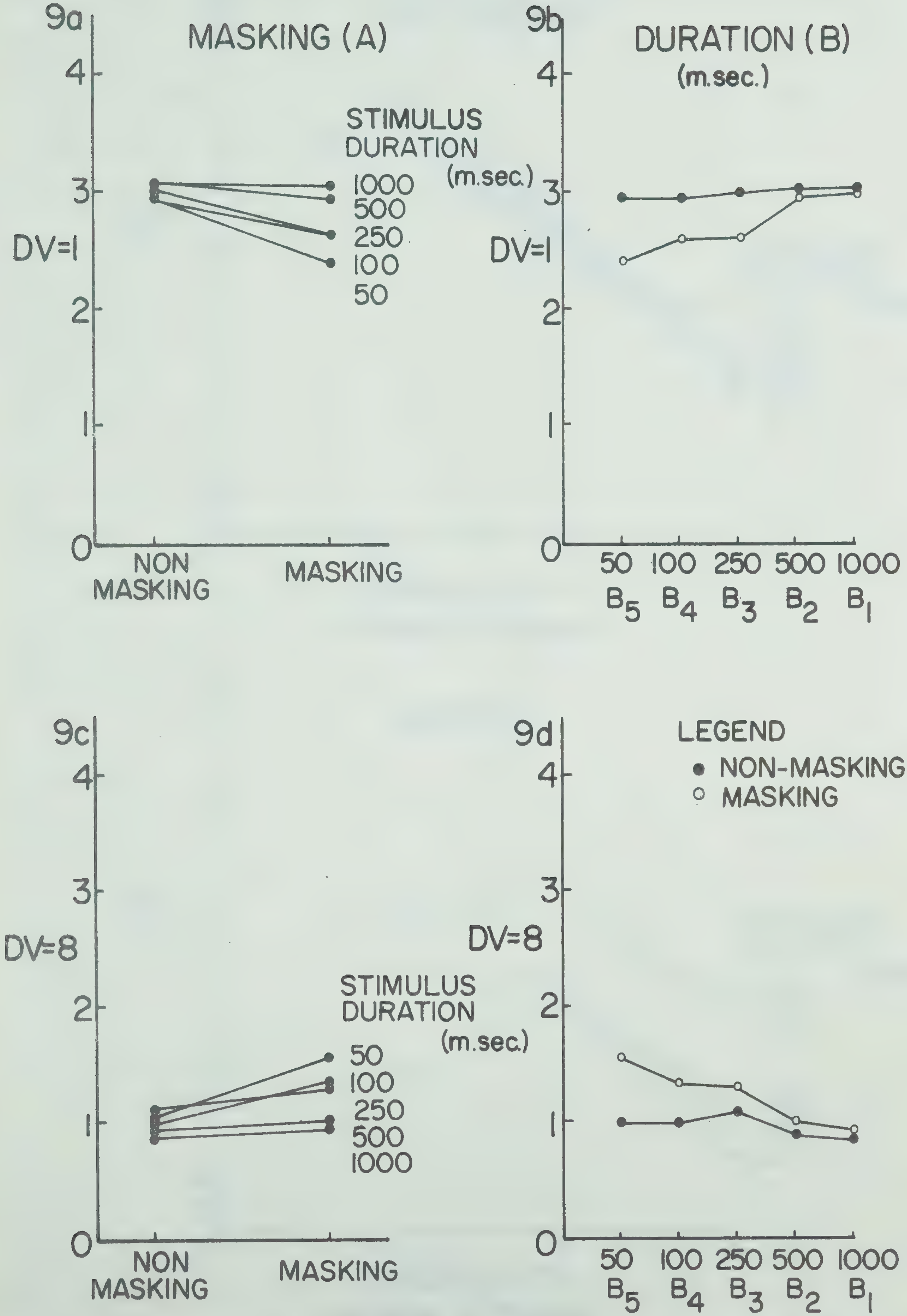


FIGURE 9 - Profile of Simple Main Effects for AB Interaction

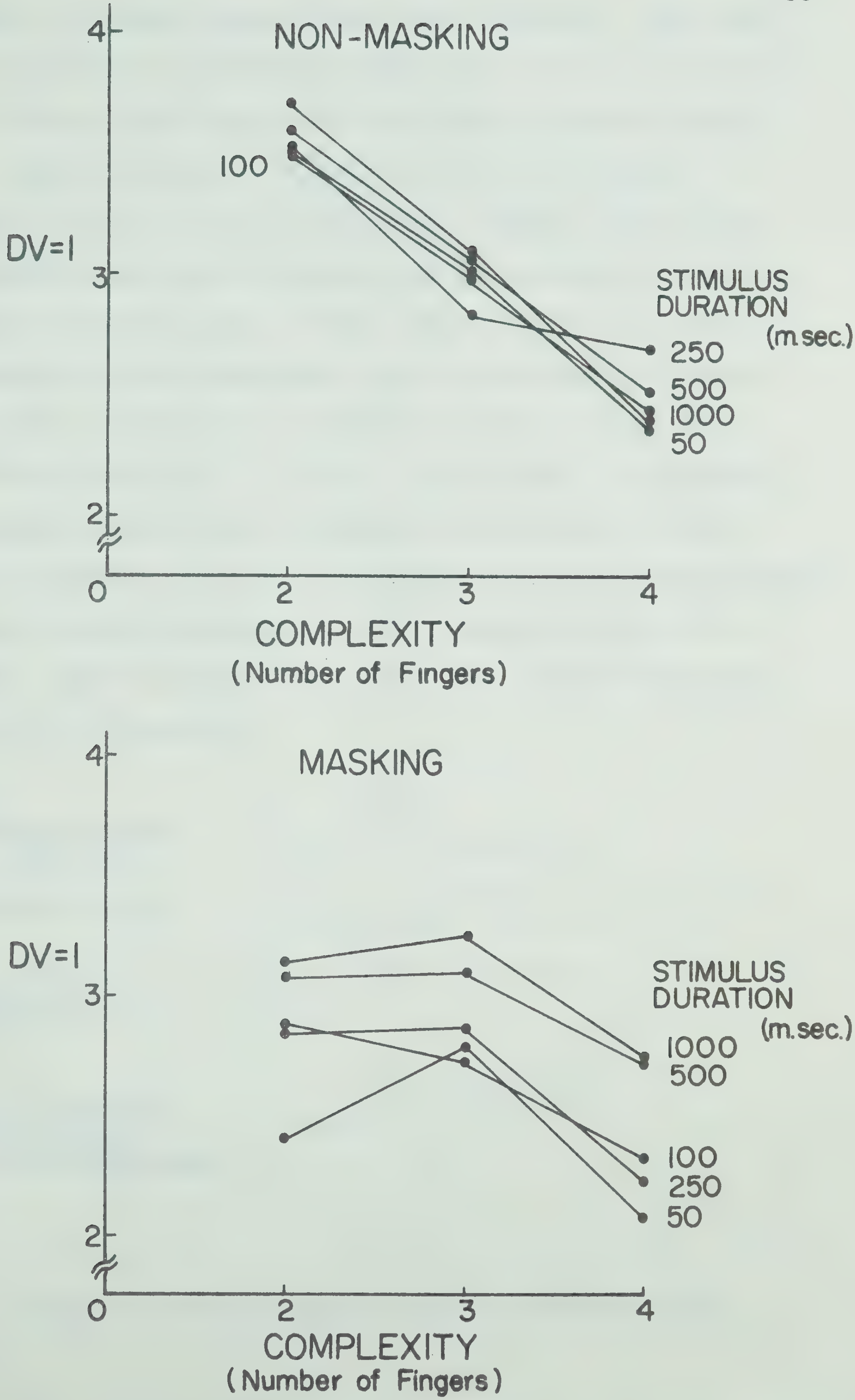
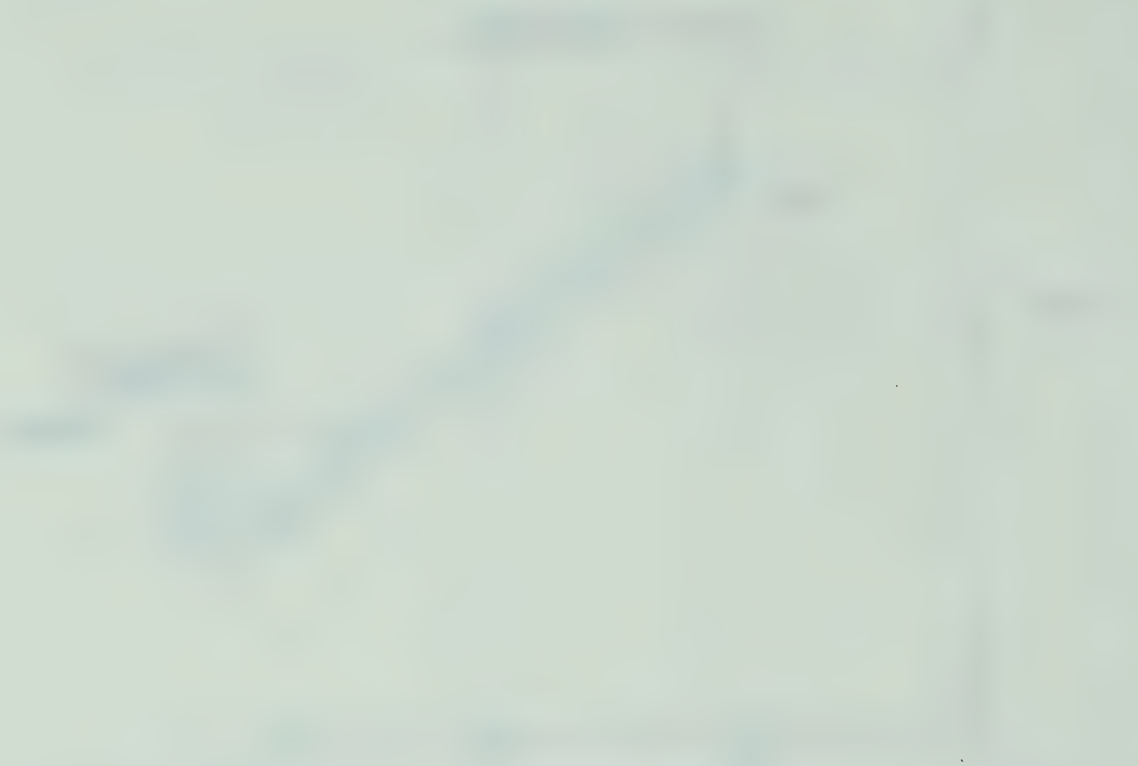


FIGURE 10 - Profile of AB Interaction for Levels of Complexity



durations < 250 milliseconds were not different. The fact that K was masked at stimulus durations < 1000 milliseconds probably means that S may have been able to impose verbal labels (code) upon the K information for all unmasked presentations and the 1000 millisecond masked presentaiton. (Ss revealed that their strategy was to attempt to covertly identify stimuli by using verbal labels.) It appeared that for masked stimulus durations < 500 milliseconds, S was no longer able to identify K information with a verbal label. At stimulus durations of 250-50 milliseconds, it appeared that S relied solely on K-location information. In this range of stimulus durations, performance dropped significantly and then remained unchanged. This interpretation of the analysis, tends to support the view that 'pure' K-location information is uncodable.

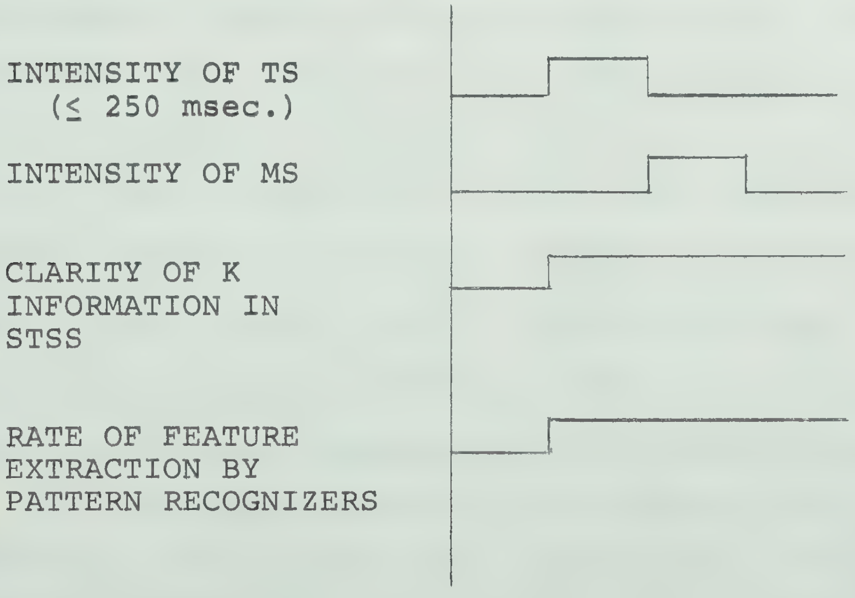


Figure 11: The Temporal Course of K Perception.

The interpretation of the results of the four experiments warrant the conclusion of the K-location information is not codable. The implication of this statement is that this form of information is not susceptible to decay nor may it be rehearsed. Rather, that K-location information has a point to point neural representation on the sensory cortex and is not a function of STM. Further, the processing of K-location information from STSS is parallel.

If K-location information is uncodable, then it is necessary to qualify the location of the process of an absolute judgement, with respect to the degree of identification. Can an absolute judgement exist for the sense of K? Technically, the answer must be no, for K information would then be a function of STM. But what of degrees of identification (coding)? Miller (1956) has shown that the absolute number of categories that a S can discriminate, along a single dimension, may be limited to 7 ± 2. But this ability is probably greater if S is not required to name (code) the categories. Recent work by Marteniuk (1971) indicates a relatively wide range of equal discriminability for the shoulder joint. If K information has a code of sub-verbal nature, then it might be expected that this system has a greater capacity to transmit unattended information than one with a verbal code. Such an implication seems almost necessary to explain how man is able to perform cognitive activities without regression to his physical awareness.

The interpretation of the nature of K is depicted in Figure 11. It suggests that K perception is time gated; K-location information is organized into sensory chunks, which probably overlap, and therefore allow for the perception of motion.

Masking x Complexity (AC) Interaction

H_{10}: $\sigma^2_{\alpha\gamma} = 0$

In hypothesis 10, it was suggested that there was zero interaction between Masking (A) and Complexity (C). This hypothesis was accepted for simple discrimination errors (DV = 2 and 3), but was rejected on DV = 1, 5, 6, and 8 (Table XII).

TABLE XIV

ANOVA OF THE SIMPLE MAIN EFFECTS OF A ON C

DV = 1

Source	Sum of Squares	df	Mean Squares	F
A for c_1	32	1	32.00	34.41**
A for c_2	0	1	0	
A for c_3	0	1	0	
Within Cell	1980	2130	0.93	

Note: $F_{.99}$ (1,2130) for α = .01 is 6.63

The null hypothesis of homogeneity of variance for factor A at c_1 was rejected, while it was accepted for factor A at c_2 and c_3.

TABLE XV

ANOVA OF THE SIMPLE MAIN EFFECTS OF C ON A

DV = 1

Source	Sum of Squares	df	Mean Square	F
C for a_1	75	2	37.5	40.32**
C for a_2	21	2	10.5	11.29**
Within Cell	1980	2130	0.93	

Note: $F_{.99}$ (2,2130) for $\alpha = .01$ is 4.61

Therefore, Hypothesis 10 was rejected for factor C at a_1 and a_2.

Discussion

Prior to interpreting the AC (Masking x Complexity) interaction, consideration of Experiments I and II should be made. The investigation of man's ability to detect unknown K finger patterns revealed that with four possible stimulus loads, S operates as though there were only three significantly different loadings; 2- and 3-finger stimuli were perceived as the same.

The analysis of the simple main effects of A for c_1-c_3 (Table XIV) revealed that Masking was only significant for 2-finger patterns. This fact was confirmed by the analysis of the simple main effects of C for a_1 and a_2 (Table XV). The means for the Masking x Complexity interaction are graphed in Figures 12 and 13.

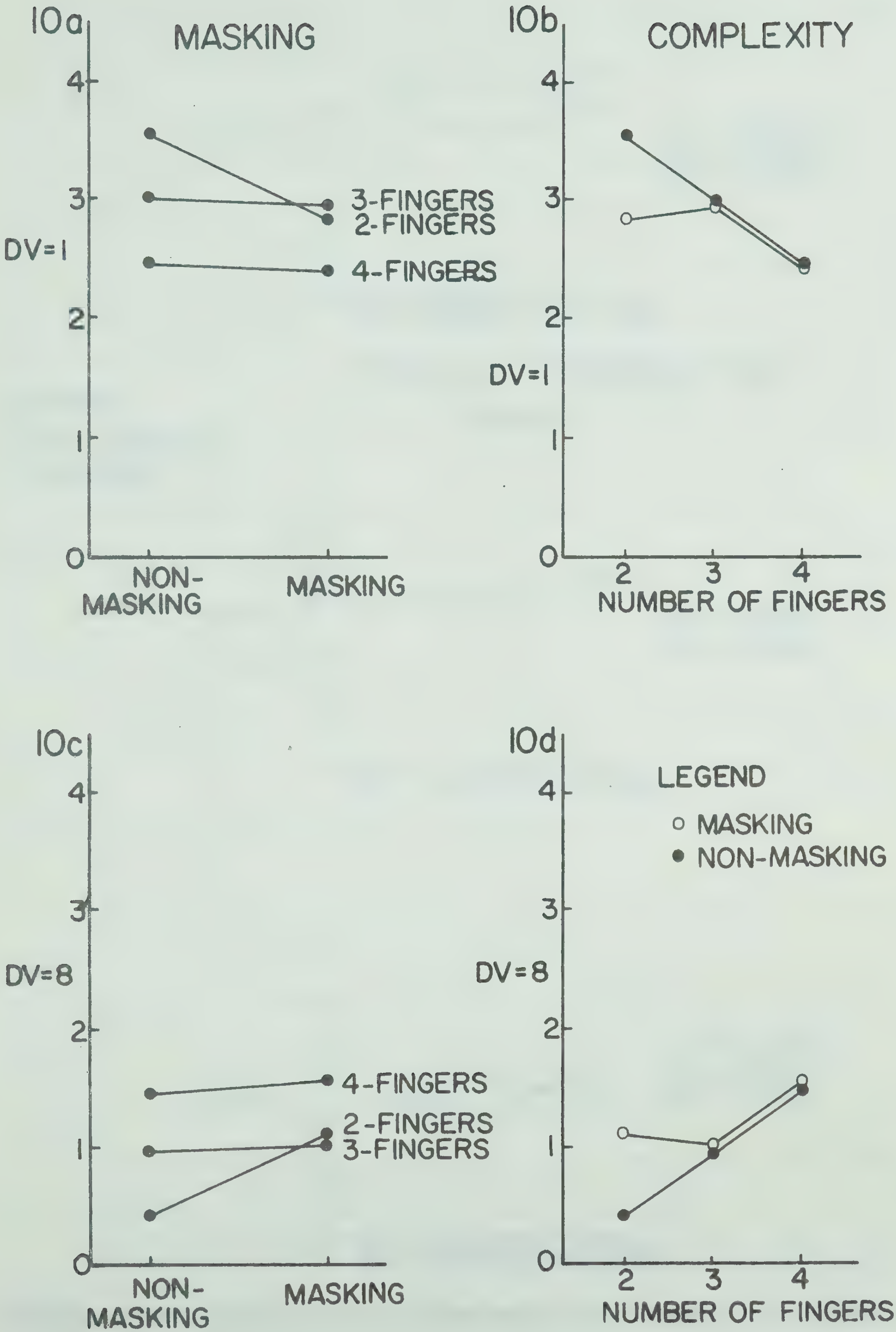


FIGURE 12 - Profile of Simple Main Effects for AC Interaction

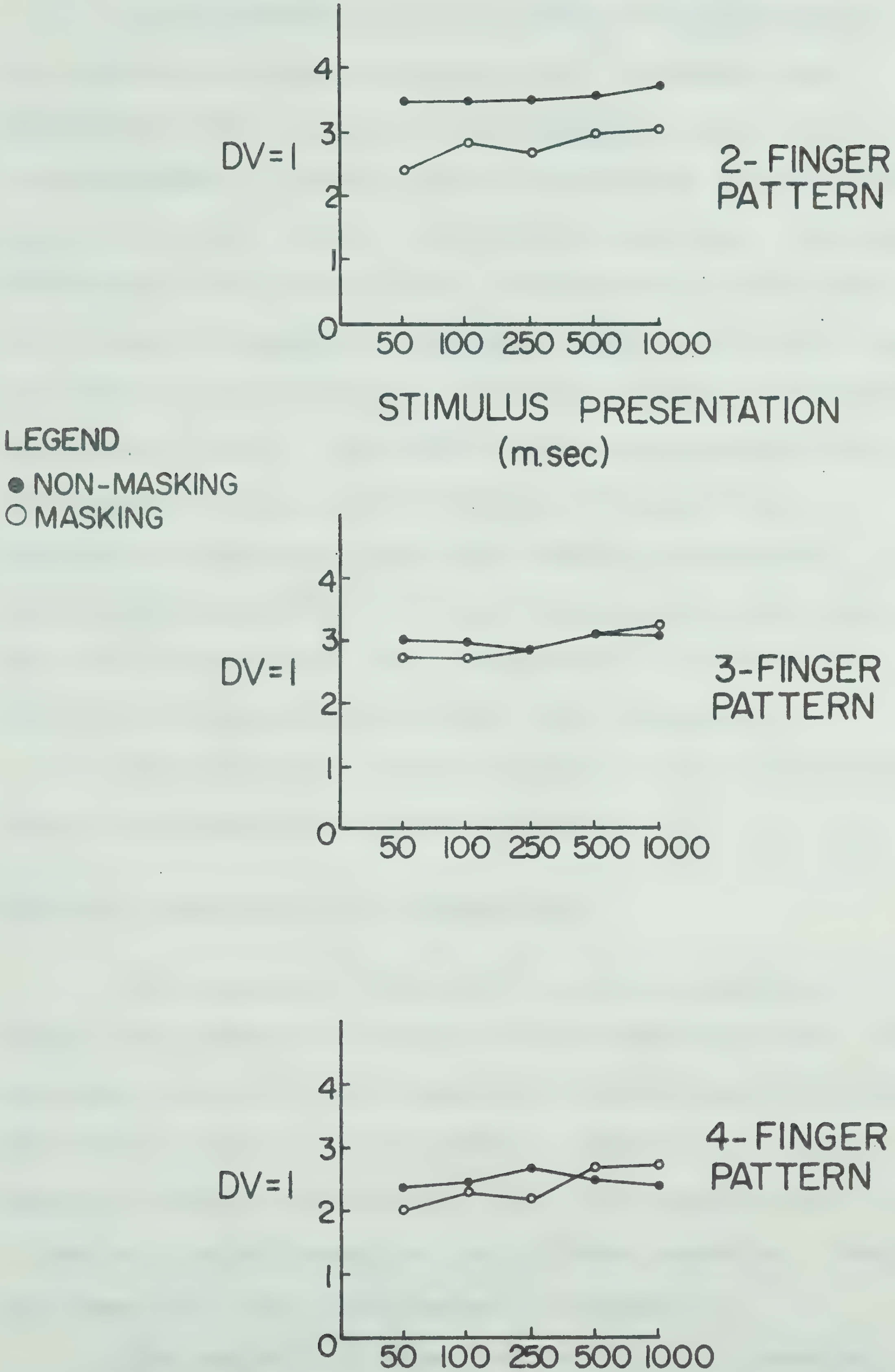


FIGURE 13 - Profile of AC Interaction for Levels of Duration

In confirmation of the results of Experiments I and II, the AC interaction suggested that a maximal "set uncertainty" for an actually low stimulus load, placed S at a disadvantage. Further, the AC interaction revealed that masking was not a linear function of complexity, but rather of "relative set uncertainty"; masking being most effective for 2-finger K patterns. Because K masking was not a linear function of complexity, it is assumed uncodable (Teichner and Sadler, 1962). Additional evidence suggesting that K was uncodable came from the absence of significant BC (Duration x Complexity) and ABC (Masking x Duration x Complexity) interactions. This evidence arose from the fact that non-interactions imply independence; consequently, stimulus duration and complexity were independent.

Because DV = 8 was the reciprocal of 1, the analysis of the AC interaction was not extended to it.

Masking x Complexity (AC) Interaction

The analysis (Tables XLII to XLIV, Appendix E) of the simple main effects of Masking (A) on Complexity (C), for the ommission error (DV = 5), suggested that Masking was significant for all levels of complexity. However, the similar analysis (Tables XLV to XLVII) for the invention error (DV = 6) was only significant for the 2-finger patterns. The means for these two DVs are graphed in Figure 14.

The analysis of dependent variable 5 (a sophisticated ommission error) suggested that it was different for each

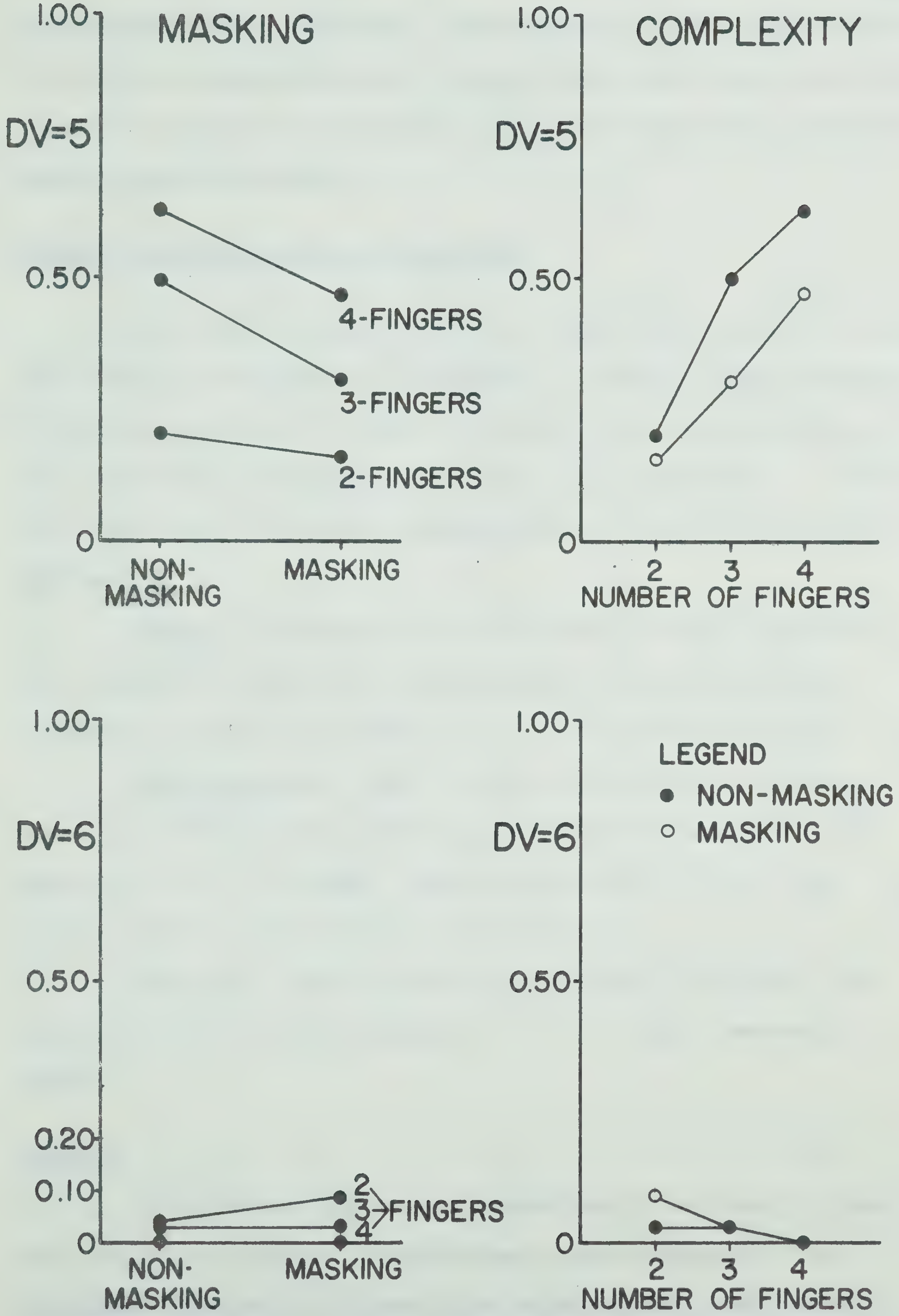


FIGURE 14 - Profile of AC Interaction for DV = 5 and 6

information load. However, the analysis of dependent variable 6 (a gross invention error) implied that only when, the "set" to actual stimulus uncertainty ratio was smallest, did this gross invention occur.

Trials, Replications, and Subjects

One 6-way Anova, for DV = 1 to 8, was carried out upon the Masking x Duration x Complexity x Trials x Replications x Subjects design, in order to qualify the interpretation of the 3-way Anova on Masking, Duration, and Complexity. Excerpts from this 6-way Anova are summarized in Tables XLVIII to L of Appendix E.

Trials. Across the six different trials (patterns) per complexity level, S's performance was significantly different on all DVs, except DV = 6 (a gross invention).

Replications. Over the two replications of each trial, Ss demonstrated learning on only one specific error score (DV = 6). However, learning occurred on the two grosser performance scores, DV = 1 and 8.

Subjects. Each S was significantly different from the others on all DVs, except DV = 7 (a gross ommission error).

Summary

In spite of the significance, on DV = 1 and 8, for the factors of Trials, Replications, and Subjects, the preceding analyses indicated the significant interactions of Masking with Duration and Complexity.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The purpose of this series of studies was essentially exploratory in nature. The experimental design was an attempt to sample iconic, K information within STSS, and to determine whether or not K-location information was codable. Consequently, the experimental design was organized to measure K pattern detection acuity at two levels of stimulus uncertainty in order to form a bench mark, against which masked performance could be compared. The experimental design was a treatment by subjects, factorial design with two replications for each subject. Ss were six graduate physical education students between the ages of 24 and 28.

The experimental apparatus presented Ss with K patterns in a tachistoscopic fashion. The experimental task was for S to immediately reproduce, passively loaded, K-location information under the constraints of stimulus duration and complexity.

There were three factors of experimental interest: Masking with two levels (non-masking and masking); Stimulus Duration with five levels (1000, 500, 250, 100, and 50 milli-seconds); and, Stimulus Complexity with three levels (2-, 3-, and 4-finger patterns). All factors were analysed for eight dependent variables.

The findings of the four studies may be summarized under the two following areas.

Limits of K Perception: When forewarned (Experiment I) by E the informational content (complexity) of an event, S appeared to set an attentional mechanism so that each event in the stimulus receives equal attention. Consequently, S may operate on three information loadings equally well.

In experiment II, S was not forewarned of the stimulus event, and therefore, individual events within low-load stimuli received less relative attention, than those same singular events, within high-load stimuli. Relative set uncertainty, defined by the ratio of actual stimulus uncertainty to the maximal event uncertainty, seemed to be the determining factor of performance. That is, in uncertainty, perforamnce was not found to be a monotonic function of stimulus complexity.

Backward Masking: In Experiments III and IV, the main effects of Masking, Duration, and Complexity were found significant at the .01 level of confidence. However, Masking interacted with Duration and Complexity.

Duration

In Experiment III, the five unmasked durations were not significantly different. Only the masked stimulus duration of 1000 milliseconds showed no performance decrement. Verbal labelling was suggested as the reason for this sudden perforamnce change. Masked stimulus durations of 500, 250, 100, and 50 milliseconds showed significantly reduced

detection performance. Of this range of durations, 250, 100, and 50 milliseconds were not significantly different from each other, but each was different from the 500 millisecond duration. This difference would seem to imply coding in kinesthesis. However, the greatest weight of evidence, the similarity of 250, 100, and 50 millisecond durations, suggests the absence of coding in kinesthesis.

Complexity

Performance under K backward masking was not a linear function of stimulus complexity; low-load stimuli (2-finger patterns) were more affected than high-load stimuli.

Conclusions

Based upon the above results, the following conclusions were made:

In uncertainty Ss resolve 1- to 4-finger K patterns into three operational loads; 2- and 3-finger patterns were treated the same. Performance for both simple detection and when backward masked, are not linear functions of complexity, but rather of relative set uncertainty. Therefore, it was concluded that K-location information is uncodable, and is a function of the acuity of a reflexive system.

Performance in K STSS appears to be based upon uncodable information. When allowed to dwell upon such information for one second or more, a S seems to be able to form its verbal counterpart.

BIBLIOGRAPHY

BIBLIOGRAPHY

Adams, J. A. Human Memory. New York: McGraw-Hill, 1967.

Adams, J. A. and Dijkstra, S. "Short term memory for motor responses." Journal of Experimental Psychology, 1966, 71, 314-18.

Alluisi, E. A. "Conditions affecting the amount of information in absolute judgements." Psychological Review, 1957, 64, 97-103.

Alluisi, E. A. and Sidorsky, R. C. "The empirical validity of equal discriminability scaling." Journal of Experimental Psychology, 1958, 86-95.

Alpern, M. "Metacontrast." Journal of Optical Society of America, 1953, 43, 648-57.

Ascoli, K. M. and Schmidt, R. A. "Attention demand during storage of traces in motor short-term memory." Acta Psychologica, 1970, 34, 497-504.

Atkinson, R. C. and Shiffrin, R. M. "Human memory: a proposed system and its control processes." The Psychology of Learning and Motivation: Advances in Research and Theory. Edited by K. W. Spence and J. T. Spence. Vol II. New York: Academic Press, 1968.

Attneave, R. Applications of Information theory to Psychology. New York: Holt, Rinehart, and Winston, 1959.

Averbach, E. and Coriell, A. S. "Short-term memory in vision." Bell System Technical Journal, 1961, 40, 309-28.

Botelho, S. Y. "Proprioceptive, vestibular, and cerebellar mechanisms in the control of movement." Physical Therapy, 1965, 45, 667-76.

Bower, G. H. "A multicomponent theory of the memory trace." The Psychology of Learning and Motivation: Advances in Research and Theory. Edited by K. W. Spence and J. T. Spence. Vol. I. New York: Academic Press, 1967.

Boynton, R. M. "On-responses in the human visual system as a function of adaptation level." Journal of the Optical Society of America, 1957, 47, 275-86.

Boynton, R. M. "Some temporal factors in vision." Sensory Communication. Edited by W. A. Rosenblith. New York: Wiley, 1961.

________. "Spatial vision." Annual Review of Psychology, 1962, 13, 171-200.

Broadbent, D. E. "A mechanical model of human attention and immediate memory." Psychological Review, 1957, 64, 205-15.

________. Perception and Communication. New York: Pergamon Press, 1958.

Broadbent, D. E. and Gregory, M. "On the recall of stimuli presented alternately to two sense organs." Quarterly Journal of Experimental Psychology, 1961, 13, 103-9.

Brown, J. "Information, redundancy, and decay of the memory trace." Mechanization of Thought Processes. Symposium No. 10 of the Natinal Physical Laboratory, Vol. II. London: H.M.S.O., 1958.

________. "Some tests of the decay theory of memory." Quarterly Journal of Experimental Psychology, 1958, 10, 12-21.

Brown, K.; Lee, J; and Ring, P. "The sensation of passive movement at the metatarsal-phalangeal joint of the great toe in man." Journal of Physiology, 1954, 126, 448-58.

Bruner, J. "On perceptual readiness." Psychological Review, 1957, 64, 123-50.

Carre, F. A. "Increasing torque as a kinesthetically dependent variable in short-term memory." Unpublished M.A. thesis, Faculty of Physical Education, University of Alberta, 1969.

Chase, R.; Rapin, I.; Gilden, L; Sutton, S.; and Guilfoyle, G. "Studies on sensory feedback: II. Sensory feedback influences on keytapping motor tasks." Quarterly Journal of Experimental Psychology, 1961, 13, 153-67.

Chernikoff, R. and Taylor, F. V. "Reaction time to kinesthetic stimulation resulting from sudden arm displacement." Journal of Experimental Psychology, 1952, 43, 1-8.

Conrad, R. "Acoustic confusions in immediate memory." British Journal of Psychology, 1964, 55, 75-84.

Conrad, R. and Hille, B. A. "The decay theory of immediate memory and paced recall." Canadian Journal of Psychology, 1958, 12, 1-6.

Crafts, J. L. and Hinrichs, J. V. "Short-term retention of simple motor responses: similarity of prior and succeeding responses." Journal of Experimental Psychology, 1971, 87, 297-302.

Dick, A. O. "Relations between the sensory register and short-term storage in tachistoscopic recognition." Journal of Experimental Psychology, 1969, 82, 278-84.

________. "Visual processing and the use of redundant information in tachistoscopic recognition." Canadian Journal of Psychology, 1970, 24, 133-41.

________. "Perception as information processing: a stage analysis." Human Development and Cognitive Processes. Edited by J. Eliot. New York: Holt, Rinehart, and Winston, 1971.

Donchin, E. "Retroactive visual masking - the effect of test flash duration." Vision Research, 1967, 7, 79-89.

Dukes, W. "The effect of direction, pause and rest on a replacement accuracy task." Unpublished M.Sc. Thesis, Faculty of Physical Education, University of Alberta, 1970.

Efron, R. "Effect of stimulus duration on perceptual onset and offset latencies." Perception and Psychophysics, 1970a, 8, 231-34.

________. "The minimum duration of a perception." Neuropsychologia, 1970b, 8, 57-63.

Eliot, J., ed. Human Development and Cognitive Processes. New York: Holt, Rinehart, and Winston, 1971.

Eriksen, C. W. "Temporal luminance summation effects in backward and forward masking." Perception and Psychophysics, 1966, 1, 87-92.

Eriksen, C. W. and Collins, J. F. "Backward masking in vision." Psychonomic Science, 1964, 1, 101-2.

________. "A reinterpretation of one form of backward and forward masking in visual perception." Journal of Experimental Psychology, 1965, 70, 343-51.

________. "Some temporal characteristics of visual pattern perception." Journal of Experimental Psychology, 1967, 74, 476-84.

Eriksen, C. W. and Collins, J. F. "Sensory traces versus the psychological moment in the temporal organization of form." Journal of Experimental Psychology, 1968, 77, 376-82.

________. "Temporal course of selective attention." Journal of Experimental Psychology, 1969, 80, 254-61.

Eriksen, C. W.; Collins, J. F.; and Greenspoon, T. S. "An analysis of certain factors responsible for monotonic backward masking functions." Journal of Experimental Psychology, 1967, 75, 500-7.

Eriksen, C. W. and Hake, H. W. "Absolute judgements as a function of stimulus range and number of stimulus and response categories." Journal of Experimental Psychology, 1955, 49, 323-32.

Eriksen, C. W. and Hoffman, M. "Form recognition at brief duration as a function of adapting field and interval between stimulations." Journal of Experimental Psychology, 1963, 66, 485-99.

Eriksen, C. W. and Lappin, J. S. "Luminance summation - contrast reduction as a basis for certain forward and backward masking effects." Psychonomic Science, 1964, 1, 313-4.

Eriksen, C. W. and Rohrbaugh, J. "Visual masking in multielement displays." Journal of Experimental Psychology, 1970, 83, 147-54.

Eriksen, C. W. and Steffy, R. A. "Short term memory for retroactive interference in visual perception." Journal of Experimental Psychology, 1964, 5, 423-34.

Fehrer, E. "Effect of stimulus similarity on retroactive masking." Journal of Experimental Psychology, 1966, 71, 612-15.

Festinger, L. and Canon, L. K. "Information about spatial location based on knowledge about efference." Psychological Review, 1965, 72, 373-84.

Fitts, P. M. "Engineering psychology and equipment design." Handbook of Experimental Psychology, Edited by S. S. Stevens, New York: Wiley, 1951.

Fitts, P. M. "Perceptual-motor skill learning." Categories of Human Learning. Edited by A. W. Melton. New York: Academic Press, 1964.

Fitts, P. M. and Posner, M. I. Human Performance. Belmont, California: Brooks-Cole, 1968.

Fleishman, E. A. and Rich, S. "Role of kinesthesis and spatial-visual abilities in perceptual-motor learning." Journal of Experimental Psychology, 1963, 66, 6-11.

Garner, W. R. "The stimulus in information processing." American Psychologist, 1970, 25, 350-8.

Garner, W. R. and Hake, H. W. "The amount of information in absolute judgements." Psychological Review, 1951, 58, 446-59.

Garner, W. R. and Creelman, C. D. "Effect of redundancy and duration on absolute judgements of visual stimuli." Journal of Experimental Psychology, 1964, 67, 168-72.

Garner, W. R. and Lee, W. "An analysis of redundancy in perceptual discrimination." Perceptual and Motor Skills, 1962, 15, 367-88.

Garner, W. R. and McGill, W. J. "The relation between information and variance analysis." Psychometrika, 1956, 21, 2, 9-28.

Gibbs, C. B. "The continuous regulation of skilled response by kinesthetic feedback." British Journal of Psychology, 1954, 45, 24-39.

________. "Servo-control systems in organisms and the transfer of skill." Skills. Edited by D. Legge. Middlesex, England: Penguin, 1970.

Greenwald, A. G. "Sensory feedback mechanisms in performance control, with special reference to the ideo-motor mechanism." Psychological Review, 1970, 77, 73-99.

Haber, R. N. and Hershenon, M. "Effects of repeated exposures on the growth of the percept." Journal of Experimental Psychology, 1965, 69, 40-46.

Haber, R. N. and Standing, L. G. "Direct measures of short-term visual storage." Quarterly Journal of Experimental Psychology, 1969, 21, 43-54.

Harter, R. M. "Excitability cycles and cortical scanning: a review of two hypothesies of central intermittency in perception." Psychological Bulletin, 1967, 68, 47-58.

Harris, J. D. "The decline of pitch discrimination with time." Journal of Experimental Psychology, 1952, 43, 96-9.

Higgins, J. R. and Angel, R. W. "Correction of tracking errors without sensory feedback." Journal of Experimental Psychology, 1970, 84, 412-6.

Hinrichs, J. V. "Prestimulus and post-stimulus cuing of recall order in the memory span." Psychonomic Science, 1968, 12, 261-2.

Homma, S.; Kano, M.; and Takano, K. "On the phasic stretch of the annulospiral endings." Symposium on Muscles Receptors. Edited by D. Barker, Hong Kong: Hong Kong University Press, 1962.

Honzik, C. H. "The role of kinesthesis in maze learning." Science, 1936, 84, 373-80.

Howard, I. P. and Templeton, W. B. Human Spatial Organization. London: Wiley and Sons, 1966.

Hughes, M. J. "Visual and kinesthetic short-term memory of a constant weight load." Unpublished M. Sc. Thesis, Faculty of Physical Education, University of Alberta, 1969.

Kahneman, D. "Method, findings, and theory in studies of visual masking." Information-Processing Approaches to Visual Perception. Edited by R. N. Haber. New York: Holt, Rinehart, and Winston, Inc., 1969.

Keele, S. W. "Movement control in skilled motor performance." Psychological Bulletin, 1968, 70, 387-403.

Keele, S. W. and Chase, W. G. "Short-term visual storage." Information-Processing Approaches to Visual Perception. Edited by R. N. Haber. New York: Holt, Rinehart and Winston, Inc., 1969.

Keele, S. W. and Posner, M. I. "Skill Learning." Handbook of Research on Teaching, American Educational Research Association, 1972 (in press).

Konorski, J. Integrative Activity of the Brain. New York: University of Chicago Press, 1967.

Labbs, G. J. "Cue effects in motor STM." Unpublished Ph.D. Dissertation, Department of Psychology, University of Oregon, 1971.

Lashley, K. S. "The problem of serial order in behaviour." Cerebral Mechanisms in Behavior. Edited by L. A. Jefferies. New York: Wiley and Sons, 1951.

Laszlo, J. I. and Bairstow, P. J. "Accuracy of movement, peripheral feedback, and efference copy." Journal of Motor Behaviour, 1971, 3, 241-52.

Mackworth, J. "The visual image and the memory trace." Canadian Journal of Psychology, 1962, 16, 48-56.

Mackworth, J. "The effect of the response upon immediate memory span." Canadian Journal of Psychology, 1962, 16, 120-27.

________. "The duration of the visual image." Canadian Journal of Psychology, 1963, 17, 62-81.

________. "The relation between the visual image and the post-perceptual immediate memory." Journal of Verbal Learning and Verbal Behaviour, 1963, 2, 75-85.

Marteniuk, R. G. "An informational analysis of active kinesthesis," Journal of Motor Behaviour, 1971, 3, 69-77.

Massaro, D. W. "Effect of masking tone duration on perceptual auditory images." Journal of Experimental Psychology, 1971, 87, 146-8.

Matthews, P. A. "Muscle spindles and their motor control." Psychological Review, 1964, 44, 219-88.

Mayzner, M. S.; Tresselt, M. E.; and Helfer, M. S. "A provisional model of visual information processing with sequential inputs." Psychonomic Monogram Supplement, 1967, 2, Whole No. 23, 91-108.

McClements, J. D. "Recall of movement distance and starting position from short-term memory." Unpublished M.Sc. Thesis, Faculty of Physical Education, University of Alberta, 1969.

Merton, P. A. "Human position sense and sense of effort." Symposium of the Society for Experimental Biology, 1964, 18, 387-400.

Mewhort, D. J.; Merikle, P. M.; and Bryden, M. P. "On the transfer from iconic to short-term memory." Journal of Experimental Psychology, 1969, 81, 89-94.

Miller, G. A. "Magical number seven--plus or minus two." Psychological Review, 1956, 63, 81-97.

________. "Encoding the unexpected." Proceedings from the Royal Society of Britain, 1968, 171, 361-75.

Morgan, J. J. "The speed and accuracy of motor adjustment." Journal of Experimental Psychology, 1917, 2, 225-48.

Morton, J. "The role of memory in the attention process." Acta Psychologica, 1970, 33, 271-9.

Moyst, V. H. "Visual and kinesthetic short-term memory in a free-moving load system." Unpublished M.Sc. Thesis, Faculty of Physical Education, University of Alberta, 1969.

Neisser, U. "Decision time without reaction time: experiments in visual scanning." American Journal of Psychology, 1963, 76, 376-85.

________. Cognitive Psychology. New York: Appleton-Century-Crofts, 1967.

Neisser, U.; Novick, R.; and Lazar R. "Searching for ten targets simultaneously." Perceptual and Motor Skills, 1963, 17, 955-61.

Norman, D. A. "Memory while shadowing." Quarterly Journal of Experimental Psychology, 1969a, 21, 85-93.

________. Memory and Attention. New York: Wiley and Sons, 1969b.

________. "Comments on the information structure of memory." Acta Psychologica, 1970 a, 33, 293-303.

Norman, D. A. and Rumelhart, D. E. "A system for perception and memory." Models of Human Memory. Edited by D. A. Norman, New York: Academic Press, 1970b.

Patrick, J. "Effects of interpolated motor activities in short-term memory." Journal of Motor Behaviour, 1971, 3, 39-48.

Pepper, R. L. and Herman, L. M. "Decay and interference effects in the short-term retention of a discrete motor act." Journal of Experimental Psychology, 1970, 83, 1-18.

Pollack, I. "Message uncertainty and measage reception." Journal of Acoustical Society of America, 1959, 31, 1500-8.

Posner, M. I. "Immediate memory in sequential tasks." Psychological Bulletin, 1963, 60, 333-49.

________. "Information reduction in the analysis of sequential tasks." Psychological Review, 1964, 71, 491-504.

________. "Rate of presentation and order of recall in immediate memory." British Journal of Psychology, 1964, 55, 303-6.

________. "Components of skilled performance." Science, 1966, 152, 1712-8.

Posner, M. I. "Characteristics of visual and kinesthetic codes." Journal of Experimental Psychology, 1967a, 75, 103-7.

________. "Short-term memory systems in human information processing." Acta Psychologica, 1967b, 27, 267-84.

________. "Abstraction and the process of recognition." The Psychology of Learning and Motivation: Advances in Research and Theory. Vol. III. Edited by G. H. Bower and J. T. Spence. New York: Academic Press, 1969.

Posner M. I. and Keele, S. W. "Decay of visual information from a single letter." Science, 1967, 158, 137-9.

Posner, M. I. and Konick, A. F. "Short-term retention of visual and kinesthetic information." Organizational Behaviour and Human Performance, 1966a, 1, 71-86.

________. "On the role of interference in short-term memory." Journal of Experimental Psychology, 1966b, 72, 221-231.

Posner, M. I. and Mitchell, R. "Chronometric analysis of classification." Psychological Review, 1967, 74, 392-409.

Posner, M. I. and Rossman, E. "Effect of size and location of information transforms upon short-term retention." Journal of Experimental Psychology, 1965, 70, 496-505.

Postman, L. "Short-term memory and incidental learning." Categories of Human Learning. Edited by A. W. Merton. New York: Academic Press, 1964.

Poulton, E. C. "Sequential short-term memory: some tracking experiments." Ergonomics, 1963, 6, 518-22.

Raab, D. H. "Backward masking." Psychological Bulletin, 1963, 60, 118-129.

Reitman, J. S. "Computer simulation of an information-processing model of short-term memory." Models of Human Memory. Edited by D. A. Norman, New York: Academic Press, 1970.

Ronco, P. G. "An experimental quantification of kinesthetic sensation: extent of arm movement." The Journal of Psychology, 1963, 55, 227-38.

Rose, J. E. and Mountcastle, V. B. "Touch and Kinesthesis." Handbook of Physiology. Edited by J. Field et al., Washington, D. C.: American Physiological Society, 1959.

Ruch, T. C.; Patton, H. D.; Woodbury, J. W.; and Towes, A. L. Neurophysiology. Philadelphia: Saunders, 1961.

Rumelhart, D. E. "A multi-component theory of the perception of briefly exposed visual displays." Journal of Mathematical Psychology, 1970, 7, 191-218.

Salmela, J. H. "Peripheral and central involvement in kinesthetic short-term memory." Unpublished Ph.D. Dissertation, Faculty of Physical Education, University of Alberta, 1972.

Schiller, P. H. "Single unit analysis of backward visual masking and metacontrast in the cat lateral geniculate nucleus." Vision Research, 1968, 8, 855-66.

Schmidt, R. A. and Ascoli, K. M. "Attention demand during storage of traces in motor short-term memory." Acta Psychologica, 1970, 34, 497-504.

Sharp, R. H. "Processing demands of kinesthetic information in short-term memory." Unpublished M.A. Thesis, Faculty of Physical Education, University of Alberta, 1971.

Smith, M. C. and Schiller, P. H. "Forward and backward masking: a comparison." Canadian Journal of Psychology, 1966, 20, 191-97.

Smith, F. and Carey, P. "Temporal factors in visual information processing." Canadian Journal of Psychology, 1966, 20, 337-42.

Sokolov, E. Perception and the Conditioned Reflex. Oxford: Pergamon Press, 1963.

Spencer, T. J. and Shuntich, R. "Evidence for an interruption theory of backward masking." Journal of Experimental Psychology, 1970, 85, 198-203.

Sperling, G. "The information available in brief visual presentations." Psychological Monogram, 1960, 74, (Whole No. 498).

Sperling, G. "A model for visual memory tasks." Human Factors, 1963, 5, 19-31.

Sperling, G. "Successive approximations to a model for short-term memory." Acta Psychologica, 1967, 27, 285-292.

Stelmach, G. E. "Prior positioning responses as a factor in short-term retention of a simple motor task." Journal of Experimental Psychology, 1969, 81, 523-26.

Stelmach, G. E. and Barber, J. I. "Interpolated activity in short-term memory." Perceptual and Motor Skills, 1970, 30, 231-34.

Stelmach, G. E. and Bassin, S. L. "The role of overt motor rehearsal in kinesthetic recall." Acta Psychologica, 1971, 35, 56-63.

Stelmach, G. E. and Wilson, M. "Kinesthetic retention, movement extent, and information processing." Journal of Experimental Psychology, 1970, 85, 425-30.

Stevens, S. S. "The psychophysics of sensory function." Sensory Communication. Edited by W. A. Rosenblith, Cambridge, Massachusetts: The M.I.T. Press, 1961.

Stevens, S. S. and Stone, G. "Finger span: ratio scale, category scale, and jnd scale." Journal of Experimental Psychology, 1959, 57, 91-95.

Stroud, J. M. "The fine structure of psychological time." Information Theory in Psychology. Edited by H. Quastler, Glencoe, Illinois: The Free Press, 1956.

Taub, E. and Berman, A. T. "Movement learning in the absence of sensory feedback." The Neuropsychology of Spatially Oriented Behaviour. Edited by S. J. Freedman. Homewood, Illinois: Dorsey Press, 1968.

Teichner, W. H. and Olson, D. E. "A preliminary theory of the effects of task and environmental factors on human performance." Human Factors, 1971, 13, 295-344.

Teichner, W. H. and Sadler, E. "Effects of exposure time and density on visual symbol identification." Journal of Experimental Psychology, 1962, 63, 376-380.

Thompson, J. H. "What happens to the stimulus in backward masking?" Journal of Experimental Psychology, 1966, 71, 580-86.

Treisman, A. M. "Strategies and models of selective attention." Psychological Review, 1969, 76, 282-299.

Wargo, M. J. "Human operator response speed, frequency, and flexibility: a review and analysis." Human Factors, 1967, 9, 221-38.

Waugh, N. C. and Norman, D. A. "Primary memory." Psychological Review, 1965, 72, 89-104.

Weisstein, N. "Backward masking and models of perceptual processing." Journal of Experimental Psychology, 1966, 72, 232-40.

Welford, A. T. Fundamentals of Skill. London: Methuen and Company, Ltd., 1968.

White, C. T. "Temporal numerosity and the psychological unit duration." Psychological Monogram, 1963, 77 (Whole No. 575).

Wickelgren, W. A. and Whitman, P. T. "Visual very-short-term memory is nonassociative." Journal of Experimental Psychology, 1970, 84, 277-81.

Wickens, D. D. and Engle, R. W. "Imagery and abstractness in short-term memory." Journal of Experimental Psychology, 1970, 84, 268-71.

Wilberg, R. B. "Human performance theory and design." Canadian Association of Health, Physical Education and Recreation, 1969a, 36, 17-19 & 38.

________. "Response accuracy based upon recall from visual and kinesthetic short-term memory." Research Quarterly, 1969b, 40, 407-14.

________. "Effect of input rate and preview upon a unidimensional perceptual motor task." Perceptual and Motor Skills, 1969c, 28, 975-81.

Williams, H. L.; Beaver, W. S.; Spence, M. T.; and Rundell, D. H. "Digital and kinesthetic memory with interpolated information processing." Journal of Experimental Psychology, 1969, 80, 530-36.

Winer, B. J. Statistical Principles in Experimental Design, New York: McGraw-Hill Book Company, 1971.

Wood, H. "Psychophysics of active kinesthesis." Journal of Experimental Psychology, 1969, 79, 480-85.

Woodworth, R. S. "The accuracy of voluntary movement." Psychological Review Monogram Supplement. III, 13, 1899.

APPENDIX A

APPENDIX A

Order of Stimulus Presentation

Experiment I

Levels of Complexity

	Two Fingers	Three Fingers	Four Fingers
1.	1200	1220	1212
2.	1100	2120	2211
3.	2100	2110	1211
4.	2200	1210	2112
5.	1020	1120	1111
6.	1010	2210	1112
7.	2020	0112	2212
8.	2010	0211	2111
9.	2002	0121	2221
10.	2001	0221	2222
11.	1001	0212	1221
12.	1002	0122	1222
13.	0220	2011	2121
14.	0210	2012	2122
15.	0120	1022	1122
16.	0110	2021	1121
17.	0202	1012	
18.	0201	1021	
19.	0101		
20.	0102		

21.	0011	
22.	0021	
23.	0012	
24.	0022	

Experiment II

1.	2000	0020
2.	0011	0201
3.	1012	0120
4.	0101	1211
5.	2122	1212
6.	0112	0021
7.	2112	2222
8.	0110	0102
9.	0100	0121
10.	2211	2210
11.	1021	2221
12.	0010	1220
13.	1221	0200
14.	2012	2200
15.	2011	1112
16.	1010	0012
17.	2121	1122
18.	1100	2002
19.	1022	2020
20.	2010	0212
21.	1020	1111

22.	2100	0022
23.	1200	1121
24.	1210	0202
25.	1120	0220
26.	2021	2212
27.	1002	0001
28.	2111	1222
29.	2001	1001
30.	0211	1000
31.	2120	0122
32.	2110	0002
33.	0210	0221

Experiment III and IV

1.	2212
2.	1200
3.	2211
4.	1020
5.	2210
6.	1212
7.	2120
8.	2100
9.	2110
10.	2210
11.	2010
12.	1210
13.	1120

14.	0210
15.	1112
16.	2112
17.	0120
18.	1220

Legend

0 - represents no movement

1 - represents a 1 centimetre movement

2 - represents a 2 centimetre movement

APPENDIX B

TABLE XVI

THREE-WAY ANOVA

EXPERIMENTS I AND II - DV=1

Source	Sum of Squares	D.F.	Mean Squares	F
Uncertainty (A)	1313	1	1312.52	42.53**
Complexity (B)	630	2	315.15	10.21**
AB	210	2	105.14	3.41
Subjects (C)	958	7	136.88	4.44**
AC	271	7	38.66	1.26
BC	910	14	65.00	2.11
Error	432	14	30.86	

TABLE XVII

THREE-WAY ANOVA

DV=2

Source	Sum of Squares	D.F.	Mean Squares	F
Uncertainty (A)	65	1	65.33	4.46*
Complexity (B)	309	2	154.75	10.57**
AB	35	2	17.33	1.18
Subjects (C)	1400	7	200.00	13.66**
AC	56	7	8.00	0.55
BC	319	14	22.82	1.56
Error	205	14	14.64	

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

TABLE XVIII

THREE-WAY ANOVA

DV=3

Source	Sum of Squares	D.F.	Mean Squares	F
Uncertainty (A)	5	1	4.69	0.35
Complexity (B)	38	2	19.19	1.42
AB	41	2	20.31	1.50
Subjects (C)	850	7	121.43	8.99**
AC	89	7	12.74	0.94
BC	30	14	2.14	0.16
Error	189	14	13.50	

TABLE XIX

THREE-WAY ANOVA

DV=4

Source	Sum of Squares	D.F.	Mean Squares	F
Uncertainty (A)	192	1	192.00	28.38**
Complexity (B)	128	2	63.81	9.43**
AB	128	2	63.81	9.43**
Subjects (C)	85	7	12.10	1.79
AC	85	7	12.10	1.79
BC	95	14	6.76	1.00
Error	95	14	6.76	

TABLE XX

THREE-WAY ANOVA

DV=5

Source	Sum of Squares	D.F.	Mean Squares	F
Uncertainty (A)	721	1	720.75	48.68**
Complexity (B)	154	2	77.15	5.21*
AB	38	2	19.19	1.30
Subjects (C)	184	7	26.24	1.77
AC	264	7	37.65	2.54
BC	173	14	12.34	0.83
Error	207	14	14.81	

TABLE XXI

THREE -WAY ANOVA

DV=6

Source	Sum of Squares	D.F.	Mean Squares	F
Uncertainty (A)	4	1	3.52	12.20**
Complexity (B)	4	2	2.15	7.43**
AB	4	2	2.15	7.43**
Subjects (C)	3	7	0.38	1.31
AC	3	7	0.38	1.31
BC	4	14	0.29	1.00
Error	4	14	0.29	

TABLE XXII

THREE-WAY ANOVA

DV=7

Source	Sum of Squares	D.F.	Mean Squares	F
Uncertainty (A)	4	1	4.08	9.09**
Complexity (B)	8	2	3.94	8.76**
AB	4	2	2.02	4.50*
Subjects (C)	9	7	1.23	2.73*
AC	9	7	1.23	2.73*
BC	8	14	0.56	1.24
Error	6	14	0.45	

TABLE XXIII

THREE-WAY ANOVA

DV=8

Source	Sum of Squares	D.F.	Mean Squares	F
Uncertainty (A)	1302	1	1302.08	41.81**
Complexity (B)	621	2	310.69	9.98**
AB	208	2	104.15	3.34
Subjects (C)	961	7	137.32	4.41**
AC	265	7	37.80	1.21
BC	908	14	64.83	2.08
Error	436	14	31.14	

TABLE XXIV

MEANS OF STIMULUS COMPLEXITY

FOR THREE-WAY ANOVA,

EXPERIMENTS I AND II

D.V.	COMPLEXITY		
	2	3	4
1.	84.25	79.94	75.38
2.	3.62	7.62	9.75
3.	4.44	6.62	5.62
4.	4.25	1.31	0.44
5.	2.75	4.19	7.06
6.	0.69	0.13	0.00
7.	0.00	0.19	0.94
8.	15.75	20.06	24.56

TABLE XXV

NEWMAN*-KEUL'S APPLIED TO COMPLEXITY MEANS FOR THE THREE-WAY ANOVA, EXPERIMENTS I AND II

D.V.	COMPLEXITY			SHORTEST SIGNIFICANT RANGE (.01)
	4	3	2	
1. Means	75.38	79.94	84.25	
75.38		4.56**	8.87**	$W_3 = 2.46$
79.94			4.31**	$W_3 = 2.10$
84.25				
	2	3	4	
2. Means	3.62	7.62	9.75	
3.62		4.00**	6.13**	$W_3 = 1.50$
7.62			2.13**	$W_2 = 1.26$
9.75				
	4	3	2	
4. Means	0.44	1.31	4.25	
0.44		0.87**	3.81**	$W_3 = 0.79$
1.31			2.94**	$W_2 = 0.67$
4.25				
	4	3	2	
6. Means	0	0.13	0.69	
0		0.13**	0.69**	$W_3 = 0.15$
0.13			0.56**	$W_2 = 0.13$
0.69				
	2	3	4	
7. Means	0	0.19	0.94	
0		0.19**	0.94**	$W_3 = 0.22$
0.19			0.75**	$W_2 = 0.20$
0.94				
	2	3	4	
8. Means	15.75	20.06	24.56	
15.75		4.31**	8.81**	$W_3 = 2.46$
20.06			4.50**	$W_2 = 2.10$
24.56				

APPENDIX C

TABLE XXVI

MEAN PERCENTAGE SCORES PER SUBJECT, PER LEVEL OF COMPLEXITY

ACROSS 16 TRIALS, EXPERIMENT I

Subject	Complexity	DV 1	2	3	4	5	6	7	8
1	2	94	3	3					6
	3	83	13	2		2			17
	4	83	16	1					17
2	2	91	9						9
	3	73	10						27
	4	84	13	3					16
3	2	94	6						6
	3	94	2	4					6
	4	86	9	5					14
4	2	91		9					9
	3	85	2	13					15
	4	84	2	14					16

TABLE XXVI (Continued)

Subject	Complexity	1	2	3	4	5	6	7	8
5	2	100							0
	3	87	7	6					13
	4	91	3	5		1			9
6	2	81	6	13					19
	3	65	15	20					35
	4	80	9	11					20
7	2	94	3	3					6
	3	92		8					8
	4	83	6	11					17
8	2	86	14						14
	3	79	21						21
	4	62	20					2	38

TABLE XXVII

MEANS OF THE THREE LEVELS OF COMPLEXITY, (ACROSS Ss), EXPERIMENT I

D.V.	COMPLEXITY 2	3	4
1	91.37	82.25	81.62
2	5.12	9.62	9.75
3	3.50	7.87	6.25
4	-	-	-
5	-	0.25	2.12
6	-	-	-
7	-	-	0.25
8	8.62	17.75	18.37

APPENDIX D

TABLE XXVIII

MEAN PERCENTAGE SCORE PER S ACROSS

16 TRIALS, EXPERIMENT II

Subject	Complexity	DV 1	2	3	4	5	6	7	8
	1	78	-	-	19	-	3	-	22
1	2	72	-	3	20	2	3	-	28
	3	77	6	9	5	3	-	-	23
	4	83	8	6	-	3	-	-	17
	1	97	-	-	3	-	-	-	3
2	2	83	2	3	6	6	-	-	17
	3	73	9	-	2	13	-	3	27
	4	59	16	3	-	17	-	5	41
	1	91	-	-	9	-	-	-	9
3	2	80	2	6	10	2	-	-	20
	3	75	-	9	5	11	-	-	25
	4	67	5	3	-	25	-	-	33
	1	84	-	-	9	-	7	-	16
4	2	73	-	11	6	8	2	-	27
	3	83	2	5	-	10	-	-	17
	4	77	-	6	-	15	-	2	23

TABLE XXVIII (continued)

Subject	Complexity	DV 1	2	3	4	5	6	7	8
	1	94	-	-	6	-	-	-	6
5	2	84	-	3	3	8	2	-	16
	3	81	3	-	6	10	-	-	19
	4	77	5	3	-	13	-	2	23
	1	70	-	5	20	-	5	-	30
6	2	66	2	12	15	3	2	-	34
	3	74	6	12	3	3	2	-	26
	4	67	10	18	5	-	-	-	33
	1	69	3	9	13	3	3	-	31
7	2	70	5	5	8	10	2	-	30
	3	81	2	8	-	9	-	-	19
	4	68	-	14	2	14	-	2	31
	1	94	6	-	-	-	-	-	6
8	2	89	6	-	-	5	-	-	11
	3	77	17	-	-	6	-	-	23
	4	55	34	-	-	9	-	2	45

TABLE XXIX

MEANS OF THE FOUR LEVELS OF COMPLEXITY

(ACROSS Ss), EXPERIMENT II

D.V.	COMPLEXITY			
	1	2	3	4
1	84.62	77.12	77.62	69.12
2	1.12	2.12	5.62	9.75
3	1.75	5.37	5.37	6.62
4	9.87	8.50	2.62	0.87
5	0.37	5.50	8.12	12.00
6	2.25	1.37	0.25	-
7	-	-	0.37	1.62
8	15.37	22.87	22.37	30.75

TABLE XXX

NEWMAN-KEUL'S APPLIED TO COMPLEXITY MEANS,

EXPERIMENT II

D.V.		COMPLEXITY				SHORTEST SIGNIFICANT RANGE (.01)
		4	2	3	1	
1.	Means	69.12	77.12	77.62	84.62	
	69.12		8.00**	8.50**	15.50**	$W_4 = 3.65$
	77.12			0.50	7.50**	$W_3 = 3.38$
	77.62				7.00**	$W_2 = 2.94$
	84.62					
		4	3	2	1	
4.	Means	0.87	2.62	8.50	9.87	
	0.87		1.75**	7.63**	9.00**	$W_4 = 2.18$
	2.62			5.88**	7.25**	$W_3 = 2.02$
	8.50				1.37	$W_2 = 1.74$
	9.87					
		1	2	3	4	
5.	Means	0.37	5.50	8.12	12.00	
	0.37		5.13**	7.75**	11.63**	$W_4 = 1.98$
	5.50			2.62**	6.50**	$W_3 = 1.84$
	8.12				3.88**	$W_2 = 1.61$
	12.00					
		1	2	3	4	
7.	Means	0	0	0.37	1.62	
	0		0	0.37	1.62**	$W_4 = 0.44$
	0			0.37	1.62**	$W_3 = 0.40$
	0.37				1.25**	$W_2 = 0.34$
	1.62					
		1	3	2	4	
8.	Means	15.37	22.37	22.87	30.75	
	15.37		7.00**	7.50**	15.38**	$W_4 = 3.63$
	22.37			0.50	8.38**	$W_3 = 3.36$
	22.87				7.88**	$W_2 = 2.94$
	30.75					

APPENDIX E

TABLE XXXI

THREE-WAY ANOVA,

EXPERIMENTS III AND IV, DV=1

Source	Sum of Squares	D.F.	Mean Squares	F
Masking (A)	41	1	41.39	44.53**
Duration (B)	40	4	10.06	10.82**
A x B	19	4	4.80	5.17**
Complexity (C)	220	2	109.76	118.08**
A x C	49	2	24.50	26.35**
B x C	6	8	0.71	0.76
A x B x C	10	8	1.21	1.31
Error	1980	2130	0.93	

** - .01

* - .05

TABLE XXXII

THREE-WAY ANOVA

DV=2

Source	Sum of Squares	D.F.	Mean Squares	F
Masking (A)	1	1	1.16	3.64*
Duratin (B)	13	4	3.30	10.40**
A x B	2	4	0.58	1.82
Complexity (C)	69	2	34.40	108.31**
A x C	1	2	0.46	1.44
B x C	3	8	0.43	1.35
A x B x C	2	8	0.24	0.76
Error	676	2130	0.32	

TABLE XXXIII

THREE-WAY ANOVA

DV=3

Source	Sum of Squares	D.F.	Mean Squares	F
Masking (A)	8	1	7.70	35.01**
Duration (B)	7	4	1.82	8.28**
A x B	1	4	0.22	0.99
Complexity (C)	6	2	3.08	13.90**
A x C	0	2	0.17	0.78
B x C	1	8	0.12	0.53
A x B x C	2	8	0.26	1.20
Error	469	2130	0.22	

TABLE XXXIV

THREE-WAY ANOVA

DV=4

Source	Sum of Squares	D.F.	Mean Squares	F
Masking (A)	28	1	28.02	325.36**
Duration (B)	1	4	0.24	2.78*
A x B	1	4	0.32	3.76**
Complexity (C)	36	2	18.06	209.72**
A x C	29	2	14.42	167.44**
B x C	2	8	0.20	2.35**
A x B x C	2	8	0.25	2.85**
Error	183	2130	0.09	

TABLE XXXV

THREE-WAY ANOVA

DV=5

Source	Sum of Squares	D.F.	Mean Squares	F
Masking (A)	10	1	10.00	35.84**
Duration (B)	3	4	0.64	2.32*
A x B	2	4	0.57	2.07
Complexity (C)	58	2	29.07	104.14**
A x C	2	2	1.24	4.44**
B x C	3	8	0.39	1.39
A x B x C	1	8	0.16	0.56
Error	595	2130	0.28	

TABLE XXXVI

THREE-WAY ANOVA

DV=6

Source	Sum of Squares	D.F.	Mean Squares	F
Masking (A)	0	1	0.11	4.99*
Duration (B)	0	4	0.04	1.83
A x B	0	4	0.01	0.41
Complexity (C)	1	2	0.55	23.08**
A x C	0	2	0.14	5.99**
B x C	0	8	0.05	2.01*
A x B x C	0	8	0.01	0.53
Error	51	2130	0.02	

TABLE XXXVII

THREE-WAY ANOVA

DV=7

Source	Sum of Squares	D.F.	Mean Squares	F
Masking (A)	0	1	0.17	2.38
Duration (B)	0	4	0.02	0.26
A x B	0	4	0.16	2.32*
Complexity (C)	9	2	4.55	64.94**
A x C	0	2	0.27	3.89*
B x C	0	8	0.03	0.38
A x B x C	1	8	0.11	1.54
Error	149	2130	0.07	

TABLE XXXVIII

THREE-WAY ANOVA

DV=8

Source	Sum of Squares	D.F.	Mean Squares	F
Masking (A)	47	1	47.11	51.75**
Duration (B)	43	4	10.79	11.85**
A x B	16	4	4.02	4.41**
Complexity (C)	216	2	107.76	118.38**
A x C	47	2	23.67	26.00**
B x C	5	8	0.68	0.74
A x B x C	8	8	1.05	1.16
Error	1939	2130	0.91	

TABLE XXXIX

MASKING X DURATION (AB) SUMMARY TABLE

	B					
	1	2	3	4	5	Ai
A1	1998	1987	1961	1927	1925	9798
A2	1976	1922	1715	1711	1570	8895
Bj	3974	3910	3676	3637	3495	18693

TABLE XL

MASKING X COMPLEXITY (AC) SUMMARY TABLE

	1	2	3	Ai
A1	771	650	538	1959
A2	620	637	523	1780
Ck	1391	1287	1061	3739

TABLE XLI

NEWMAN-KEUL'S APPLIED TO DURATION MEANS FOR THE SIMPLE MAIN EFFECTS OF DURATION (B) ON MASKING (A)

DV = 1

B for a_1			DURATION			SHORTEST SIGNIFICANT RANGE (.01)
	B_5	B_4	B_3	B_2	B_1	
Means	2.97	2.97	3.03	3.07	3.08	
2.97		0	0.06	0.10	0.11	$W_5 = 0.30$
2.97			0.06	0.10	0.11	$W_4 = 0.29$
3.03				0.04	0.05	$W_3 = 0.27$
3.07					0.01	$W_2 = 0.24$
3.08						
Summary:	50	100	250	500	1000	
B for a_2						
	B_5	B_4	B_3	B_2	B_1	
Means	2.42	2.64	2.65	2.97	3.05	
2.42		0.22	0.23	0.55**	0.63**	$W_5 = 0.30$
2.64			0.01	0.33**	0.41**	$W_4 = 0.29$
2.65				0.32**	0.40**	$W_3 = 0.27$
2.97					0.08	$W_2 = 0.24$
3.05						
Summary:	50	100	250	500	1000	

TABLE XLII

MASKING x COMPLEXITY (AC) SUMMARY TABLE

DV = 5

	C			
	1	2	3	A_i
A_1	194	529	691	1415
A_2	151	313	507	972
C_k	346	842	1199	2387

TABLE XLIII

ANOVA OF THE SIMPLE MAIN EFFECTS OF A ON C

DV = 5

Source	Sum of Squares	df	Mean Square	F
A for c_1	3	1	2.70	9.64**
A for c_2	108	1	108.00	385.71**
A for c_3	937	1	936.57	3344.89**
Within Cell	595	2130	0.28	

Note: Critical $F_{.99}$ (1,2130) for $\alpha = .01$ is 6.63

TABLE XLIV

ANOVA OF THE SIMPLE MAIN EFFECTS OF C ON A

DV = 5

Source	Sum of Squares	df	Mean Square	F
C for a_1	1454	2	727.00	781.72**
C for a_2	291	2	146.00	159.99**
Within Cell	1980	2130	0.93	

Note: Critical $F_{.99}$ (2,2130) for $\alpha = .01$ is 4.61

TABLE XLV

MASKING x COMPLEXITY (AC) SUMMARY TABLE

DV = 6

	C 1	2	3	A_i
A_1	32.4	21.6	0	54
A_2	86.4	21.6	0	108
C_k	118.8	43.2	0	162

TABLE XLVI

ANOVA OF THE SIMPLE MAIN EFFECTS OF A ON C

DV = 6

Source	Sum of Squares	df	Mean Square	F
A for c_1	6.75	1	6.75	337.50**
A for c_2	0	1	0	
A for c_3	0	1	0	
Within Cell	51	2130	0.02	

Note: Critical $F_{.99}$ (1,2130) for α = .01 is 6.63

TABLE XLVII

ANOVA FOR THE SIMPLE MAIN EFFECTS OF C ON A
DV = 6

Source	Sum of Sqaures	df	Mean Square	F
C for a_1	2.52	2	1.26	63.00**
C for a_2	18.72	2	9.36	468.00**
Within Cell	51	2130	0.02	

Note: Critical $F_{.99}$ (2,2130) for α = .01 is 4.61

TABLE XLVIII

SUMMARY OF THREE-WAY ANOVA OF TRIALS (D)

DV	Sum of Squares	df	Mean Square	F
1	46	5	9.19	14.16**
2	19	5	3.82	16.47**
3	14	5	2.83	15.35**
4	1	5	0.19	2.80**
5	16	5	3.21	16.34**
6	0	5	0.02	0.89
7	6	5	1.11	27.55**
8	44	5	8.80	14.40**

TABLE XLIX

SUMMARY OF SIX-WAY ANOVA OF REPLICATIONS (E)

DV	Sum of Squares	df	Mean Square	F
1	8	1	8.19	12.61**
2	1	1	0.82	3.52
3	0	1	0.10	0.56
4	0	1	0.09	1.32
5	0	1	0.29	1.47
6	0	1	0.15	7.22**
7	0	1	0	0.01
8	6	1	6.34	10.38**

TABLE L

SUMMARY OF SIX-WAY ANOVA OF SUBJECTS (F)

DV	Sum of Squares	df	Mean Square	F
1	117	5	23.47	13.65**
2	29	5	5.72	8.94**
3	7	5	1.51	6.29**
4	4	5	0.87	3.95**
5	48	5	9.52	23.22**
6	2	5	0.30	15.00**
7	2	5	0.44	2.00
8	117	5	23.49	15.35**